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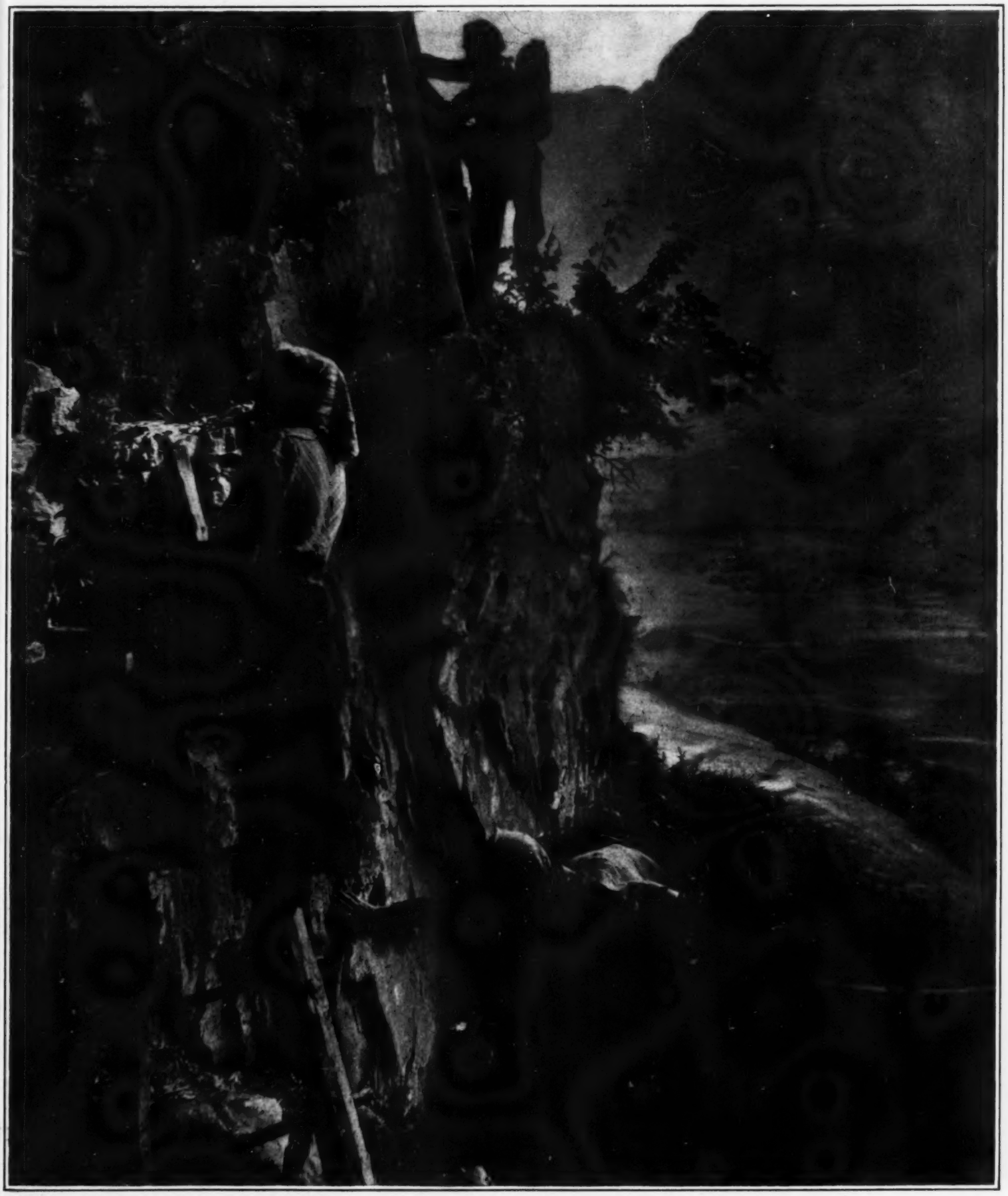


Swiss peasants on one of their local highway.

A SCENE ALONG THE LINE OF THE LEUK-LEUKERBAD RAILWAY.—[See page 408.]

The Problem of the Crippled Soldier*

What Shall Be Done With Him After the War?

By Frank B. Gilbreth

To-day there are two million men living in Europe who have suffered the loss of limbs, faculties, or both, as a result of injuries in the great war. Before this war is over this number will be enormously increased. No one who has not actually seen hundreds of wounded soldiers writhing in agony in the freight cars or the hospitals can fully realize the conditions, that exist, but the pictures and accounts from the front have been so vivid that the whole world has been aroused to a concrete expression of sympathy and efforts to alleviate the immediate suffering.

However, there has been, as yet, little or no thought given to the permanent suffering that is by far the most serious aspect of the subject. What is to be done with these millions of cripples, when their injuries have been remedied as far as possible, and when they are obliged to become again a part of the working community? At the close of the war the various countries now engaged in it will find themselves for years fully occupied in devising ways and means for paying the interest on their enormous debts. They will not be able adequately to pension and properly to provide financially for their astounding numbers of incapacitated soldiers. Neither would any system of pensioning, if that were financially possible, solve the problem, since the large majority of such cripples require interest and occupation as well as financial support. The great problem that faces the world to-day is, therefore, immediate and permanent provision for enabling these millions of crippled soldiers to become self-supporting. This is a world problem rather than a problem for those countries only that are directly involved in the war, and demands a worldwide solution.

TYPES OF CRIPPLED SOLDIERS.

The crippled soldiers are of many types, for this war is a war of all classes, and not of the professional soldiers only, as one is at times inclined to think. In all countries men from the colleges, the professions, the shops and the factories are at the front along with the usual military force. The cripples, therefore, will be of all types, and vary in training and capability as well as in the injuries that they receive. We might, therefore, roughly classify them as follows:

1. Men who have done chiefly mental work.
2. Men who have done chiefly physical work, but whose capabilities will allow them to be transferred to mental work.
3. Men who have done physical work, and whose capabilities and inclinations confine them to physical work.

The first two classes can be handled with comparative ease when crippled. The third class presents the most difficult phase of the problem. This problem might be summarized as that of teaching and fitting cripples for some sort of productive work, and specially modifying and adapting the work to the individual capabilities, preferences, difficulties and shortcomings. The problem is an exaggerated new form of vocational guidance, vocational training, and systematic placement of men.

THE PLACE OF THE EDUCATOR IN CRIPPLED SOLDIER WORK.

The educators have been quick to see their responsibilities in this work. They have provided, wherever possible, in existing or new institutions, opportunities for crippled brain workers to become productive, and have been ready and willing to devise opportunities and to furnish teaching for those previously engaged in physical work to learn and to use any mental work of which they are capable. They have, however, realized with equal rapidity their limitations in placing crippled soldiers whose bent is toward some type of physical work, as they have seen that this line of placement lies in the field of the engineer.

THE ENGINEER AND THE CRIPPLED SOLDIERS' WORK.

The engineer, both because of his training and practice, thinks largely in terms of physical capacity and its concrete results. The engineer of to-day emphasizes the human element as a factor in accomplishing results, and it is his peculiar province to make this human element most efficient. Knowing that the writer had specialized for years in this type of work, educators in the various warring countries have urged him to attack this particular branch of the crippled soldiers' problem, and to put the results of modern management in general, and of motion study in particular, at the disposal of those in active charge of training the cripples. No great amount of urging was needed. The writer has, since the war began, crossed more than a dozen European frontiers. He has visited many hospitals and recovery homes, and seen first hand the frightful need, and he returns to this country not only with the desire to be of service, but with a definite plan as to how service can be most adequately rendered.

* A paper presented before the American Society of Mechanical Engineers.

THE OUTLINED METHOD OF ATTACK.

The method of attack of the problem is as follows: It is realized that the psychological feature is an important one. A prime necessity is to inspire the cripple with the feeling that he can remain, or become, a productive member of the community. This is done by gathering data as to cripples of various types who have succeeded in becoming useful and earning members of the community. This data consists of concrete examples of men, women, or children incapacitated in any way who have been enabled by any possible means to be useful to themselves and to society. Such data has been and is being accumulated at an astonishing rate. It serves not only to encourage the cripple by suggesting that what has been done, can be done, but also by indicating immediate methods of attack upon individual problems. Back of all these individual illustrations, however, must lie a scientific method for attacking the general and the individual condition of each cripple; for diagnosing the particular case, and prescribing an adequate remedy. This is our contribution toward the solution of the problem.

THE MOTION STUDY METHOD OF ATTACK.

The motion study method of attack considers the work to be done as a *demand* for certain motions, and the proposed worker as a *supply* of certain motions. It aims

1. To consider all work from the motion study standpoint—to discover exactly,
   a. What motions *may* be used for the work.
   b. What motions *must* be used for the work.
2. To discover what motions are possible to the proposed worker.
3. To determine which type of work may best be adapted to the worker, and how.

It may be well to state that motion study considers always three groups of variables, which, in the industries, are:

1. The variables of the worker.
2. The variables of the surroundings, equipment and tools.
3. The variables of the motions.

In adapting motion study to the crippled soldiers' problem, we are considering these same three groups.

We realize that our problem is twofold in its aspect. It consists of:

1. Determining the type of work that the particular worker can best do.
2. Determining that method by which he can best be taught to do the work.

The teaching element is more important in this new phase of adequate placement than it has ever been before, because in every case a new or changed worker must be made useful, self-supporting and interested. That he become and remain interested implies the highest form of teaching and of learning.

THE SIMULTANEOUS CYCLE MOTION CHART.

The first step in adequate placement through motion study lies in visualizing the motions used, or necessary, in any given type of work. The simultaneous cycle motion chart is a device for recording and showing the inter-relation of the individual motions and cycles of motions used in any method of performing any piece of work. This motion chart was devised and is used by us in our consulting work of motion study in the industries. Here we deal mostly with those who have the use of all their limbs and faculties, but the chart is equally applicable when dealing with cripples.

The elements of a cycle of decisions and motions, either running partly or wholly concurrently with other elements in the same or other cycles, consist of the following, arranged in varying sequences:

1. Search.
2. Find.
3. Select.
4. Grasp.
5. Position.
6. Transport, loaded.
7. Assemble.
8. Use.
9. Desemble, or take apart.
10. Inspect.
11. Transport, loaded.
12. Pre-position for next operation.
13. Release load.
14. Transport, empty.
15. Wait (unavoidable delay).
16. Wait (avoidable delay).
17. Rest (for overcoming fatigue).

The simultaneous cycle motion chart is best made on cross-sectioned paper. The horizontal lines, reading from the top down, represent time. We have found that the thousandth of a minute is the best unit with which to work. The various vertical spaces are divided into anatomical groups, such as right-arm and left-arm, consisting of the sub-groups, upper arm, lower arm, wrist, thumb, first, second, third and fourth finger, and palm; right leg and left leg, with the sub-groups of thigh, knee, calf, ankle, heel and toes; trunk, with the sub-groups of forward bend, backward bend, bend to right, bend to left, twist to right, twist to left, hump, and shrug; head, with the sub-groups of forward bend, backward bend, turn to the right, turn to the left, and mouth; eyes, with the sub-groups of ball, pupil and lens. There should also be the general heading of "inspection," with the subdivisions of see, smell, touch, taste, hear, blow, and count; and the heading "posture," with the subdivisions of sit, stand, kneel, stoop, right forearm supported, left forearm supported, right hand supported, left hand supported, back supported and head supported, etc.

Charting the data in this manner makes it possible at a glance to visualize a simultaneous cycle and the elements of the cycle of work done. The various motion cycles in the method under investigation are analyzed into these elements. Through this analysis we are able to work out new sequences, cycles and methods of doing any type of work. Thus, many types of work that have been formerly considered possible only for the man in complete possession of all his members and faculties can be adapted to the maimed or crippled worker. The chart shows in a concrete form which members and faculties of the associated units or working members of the human body are doing the work, are inefficiently occupied, or are available for doing parts or all of the work. They enable us to see at a glance not only how motions are at the present being made, but the possibility of shifting these motions to other members of the worker's body. In other words, when using these charts for the crippled soldiers' work we are enabled to proceed immediately and directly to the more efficient rearrangement, distribution and assignment of the necessary motions to the different remaining members.

THE PROCESS OF OBTAINING SIMULTANEOUS CYCLE MOTION CHART DATA.

The data included in these charts is gathered through various methods of making motion studies, especially by the use of the micro-motion method and the chronocyclegraph method of recording motion data. The most skilled worker at the type of work studied is taken to the research laboratory. Here records of his methods are made with the special devices, microchronometer and the cinematograph, and also with the chronocyclegraph apparatus. The former type of records record the activity of the worker, the surroundings, equipment and tools, and also the time of the motions used. The latter records show the directions, speeds and paths of the motions. The records serve not only as data for the simultaneous cycle motion chart, but also as the most efficient of teaching devices. From the chronocyclegraph records are made of motion models that not only make it possible for teacher and learner to visualize the desired motions from all viewpoints, but that also serve as path guides in case the worker taught is of the motor type.

Until recently it has been considered "good enough practice" in the industries to teach the traditional or existing method of a successful workman. Through the methods and measuring devices of precision used in the motion study laboratory we are now able to record with exactness and in detail the methods of the most skilled workmen. By the use of the scientific method of analysis, measurement and synthesis we arrive at the method of least waste for performing the work. Through special teaching devices we then transfer the selected elements of skill and experience, in a new synthesized cycle of least waste, to workers who have never had that "all around," non-guided experience or its slowly acquired skill. Not only are the methods transferred more efficiently, but there is a great saving of time and effort to both teacher and learner, as is satisfactorily shown by learning curves of many past performances on widely varied types of work. The teaching devices, which we have specially adapted to appeal to as many types of workers as possible and to all available senses, are especially useful with crippled learners, where it is often necessary to specialize on some particular sense training.

The fatigue study that accompanies the motion study provides for the elimination of all unnecessary fatigue, and for adequate rest for overcoming necessary fatigue. Such study is imperative in the work with cripples, since the greatest of care must be taken that the maimed worker is not overtaxed.

CO-OPERATION ESSENTIAL TO THIS WORK.

While this method of attack is bringing in gratifying results, no great headway can be made with the crippled soldiers' problem without worldwide co-operation. Such co-operation has been forthcoming wherever interest in the subject has been aroused. We gratefully acknowledge the receipt of suggestions and co-operation from members of our organization, from friends in many parts of America and other countries, and particularly from the alumni and friends of our summer school of Scientific Management, and we most earnestly beg for more and more. We need photographs, records and histories of cases where cripples have been made comfortable and less fatigued in their work, and have been taught and are successfully doing work in spite of their apparently insurmountable handicaps. No incident is too trivial to be of some use, for the crippling is of every conceivable type, and every success will encourage some disheartened invalid to take up life with a new courage. We want also suggestions for adaptations of machines, tools, and other equipment or surroundings to workers. For example, we have found that typewriter manufacturers have made attachments for the use of operators having one hand only. We have seen such an operator handle the modified machine with satisfactory results. We have found that slight modification of other machines permits assigning their operating and controlling parts to the remaining limbs of the workers, and thus makes possible their successful handling by injured operators. Any kind of an adjustment or adaptation may be not only useful in its particular field, but may also form a missing link in an invention in an entirely different field. We will gladly take all data sent us and make it immediately useful to those working on the training of the injured soldiers in all countries. We have found it most profitable to think of all activity in terms of motions and decisions. Through more than thirty years of work in motion study we have facilities that make it possible to analyze all data into terms of motion economy, and thus to make it useful with the least waste in transmission or handling time.

This work of helping the crippled soldiers by teaching them to make the most of their motion possibilities should be the special contribution of the engineer in the field of social betterment. The opportunities for such work today are especially large because of the great war, but the methods that we now advise and use because of the great pressure will be available at all times. Great and wonderful as the "Safety First" movement is, and much as it has done to eliminate accidents, there will always be, although in decreasing numbers, some industrial cripples. Through the reclamation service, if we may so call it, that we are using for the war cripples to-day, we are introducing a method that will never become unavailable or unnecessary.

We beg every member of the American Society of Mechanical Engineers to co-operate in this work, with us and with our friends abroad, who are waiting to pass on the data to those who need it so sorely. It is a work that is both timely and permanent.

Welding and Cutting Metals

Present Practice in Use of Oxy-Acetylene and Oxy-Hydrogen Flames

PRESENT practice in the use of the oxy-acetylene and oxy-hydrogen flame for welding and cutting formed the subject of a paper presented by H. R. Swartley, Jr., before the recent International Engineering Congress, under the title "High Temperature Flames in Metal Working." Mr. Swartley reviews the accomplishment of the process in the metal working industries, in part, as follows:

The strength of the joint produced by autogenous welding has been a fruitful source of discussion in the application of the process, and many contentions have been advanced as to the necessity of welds of highest tensile strength. It was early found that welds having a breaking strength equivalent to that of the metal itself could be produced, but the sacrifice of elongation and reduction of area materially lessened the apparent value of such welds.

Present practice is directed toward securing a weld of good tensile strength, as compared with the strength of the plate, with high ductility, since, thereby, the service conditions are better fulfilled. The growth in understanding of such requirements has resulted in the production of methods which, combined with proper apparatus, may uniformly produce these results.

DEVELOPMENT IN WELDING TORCHES.

European practice covers the use of the low-pressure acetylene generator and injector type of blow-pipe almost exclusively, the independent-pressure type of torch having shown little development, despite its well-known economy of operation. The introduction of the process, however, in this country was accompanied by the development of the medium-pressure positive-mixture torch, utilizing both gases under independent pressure, assuring, thereby, stability and quality of the flame, heretofore not produced by the injector form of construction.

The trend of development in welding torches shows a progressive adoption by the rapidly increasing number of manufacturers in this country, of a construction which admits the gases under independent pressures. A review of exceptional performances, particularly of welding of heavy sections, covers a period coincident with the inception and exploitation of the medium-pressure form of torch with the accompanying successful acetylene generator producing that gas under pressure.

It is a prime requisite of operations carried out in the constantly multiplying instances of heavy metal-section welding, that the work be carried on continuously, on account of possible failure due to shrinkage strains and similar causes. For operations of this character it will be noted that the medium-pressure positive-mixture form of blow-pipe is almost invariably employed, due to its ability to withstand the high pre-heat temperatures to which it is subjected during the performance of the work and to the better combustion obtained.

CUTTING WITH THE OXYGEN JET.

The discovery that a jet of oxygen directed upon a previously heated steel or wrought-iron section was capable of burning the metal to iron oxide, and furnishing, thereby, a most convenient and effective means of cutting sections up to 30 inches in thickness, marked an epoch in the development of the world's metallurgical industry. It was early appreciated that, in order for oxygen metal-cutting apparatus to attain its recognized standard in metal-working fields, there were involved the factors of low-cost gas supply and minimum consumption of gases per square inch of metal oxidized.

With the establishment of oxygen-generating stations and distributing service, the first of these requirements has been met; for the second, the time and energy of apparatus manufacturers has been devoted to making it possible to substitute the oxygen-cutting torch in a rapidly increasing number of instances, where, formerly, only most laborious and expensive methods were possible.

Recent notable instances are:

Armor-plate, 16 inches thick, cut at the rate of 4 lineal inches per minute—the oxidation of the steel being effected at the rate of more than 1 square inch per second.

Cutting gun port in armor-plate 18 inches thick. Time required, 50 minutes, operation ordinarily requiring four weeks of drilling with subsequent two weeks machining time.

Fifty-two lineal feet of gun-turret top, of armor-plate 5 inches thick, was cut at the rate of 8 lineal inches per minute, after which 48 lineal feet of the edge of the plate was beveled at 15 degrees with the cutting torch, the entire cutting operation requiring 2 hours 10½ minutes. It was estimated that by former methods of drilling and then beveling on a large lathe, four weeks' time would be required and a cost entailed of about $2,000. The cost of gases for cutting by the method employed was $54.38.

A 7,500-ton cast-steel cylinder, representing a pouring of 140,000 pounds, had five risers to be removed, one being 36 inches in diameter and weighing about 15 tons. The apparent difficulty of removing the risers was quickly overcome with the cutting torch, the 36-inch riser being cut in 1¼ hours.

These cutting operations were accomplished with mechanically-guided torches employing oxygen with hydrogen as the fuel gas.

UNUSUAL APPLICATION OF AUTOGENOUS WELDING.

As indicating the wide range of application of the process, manufacturers of jewelry employ autogenous welding for the joining of precious metals requiring for their successful manipulation the production of high-temperature flames equaling the size of a needle point, under most exact adjustment and control.

Autogenously welded tube and pipe sections have formed important parts of foreign-constructed machinery. Welded sheet-metal formations of exceedingly intricate character for many years puzzled the minds of American manufacturers, as to the method of production, until the application of autogenous welding provided a solution of the problem of duplication. It is interesting to note that there are now under construction in this country industrial establishments capable of producing autogenously welded tubing, by mechanical operation, in quantities sufficient to compete with modern tube mills employing the lap-welding methods and with seamless-drawn tubing.—*The Iron Age.*

War Telephones*

Field Operator's Difficulties

By Charles Darling

WE have to thank the Japanese for indicating the potentialities of the telephone in modern warfare, since they brought this method of communication to a very fine state of development in the Russo-Japanese war. So omnipotent has the telephone become to-day on the battlefield that flag signaling has been practically abolished, and all communications there are now made by means of the field telephone. The latter instrument differs in many essentials from the ordinary house telephone, being without a bell and much more compact. The source of current is the dry cell.

Bells are too heavy to carry, and they have the further disadvantage that they can not be used for Morse code signaling. Therefore, in the field telephone a vibrator, or buzzer, is used. This serves for calling up, and can also be readily used for transmitting messages by the Morse code. In fact, the telephone is more largely used for signaling in this manner than for the transmission of the human voice, since the noise of battle frequently renders the latter indistinct, while the Morse signals can be more easily recognized under these trying conditions.

It was just 90 years ago that a retired gunner of the Royal Field Artillery demonstrated the principle of the buzzer, which was simply a modified form of electric bell.

The great feature of the newest pattern Army field telephone, the portable "D. Mark III.," is the sharp note given by its buzzer, the note being extremely clear, and, therefore, particularly valued by signalers. Not only this, but the D. Mark III. instrument is stated to use less current, so that the renewal of cells is not so frequent as with other types. The instrument has two receivers. One was strapped to the head, so that the operator's hands were free either for defense, taking notes, or other purposes. So insistent is the call of the buzzer that even if the operator was to sleep with his headpiece on, the call would wake him up. A second receiver is provided in each case, which is a very good arrangement, since two people can listen at once and check the messages. There is also thus a double chance in case the receiver cord is broken—a frequent happening since the cords are made of stranded copper, which often snaps as a result of continuous twisting.

In the first place, the operator has to see that his telephones are in good order. He must, therefore, know how the whole system works, and from time to time must test the buzzer and receiver for faults. The buzzer might be out of adjustment or the cells run down, while still another possibility is that the cord might be broken or it might be even necessary to re-wire the receiver. Secondly, the field telephonist must be able to lay his lines properly. The wire used for this purpose varies in thickness; for temporary lines thin steel wire, well varnished, is used—this being a hint from the Japanese; a single reel that a man can easily carry containing several miles of such wire. No attempt is made to pick up such wire when it has served its purpose or has become broken; in the latter case it is quicker and often better to run out another line. For more permanent telephone lines stranded steel wire, well insulated, is employed. This wire is found to be more serviceable than copper, as the latter is easily broken, for instance, by a horse's hoof. Each reel carries half a mile of this steel wire. It is laid by the field telephonist, who has to use much judgment and common sense in this work. Lines are often laid along the top of a hedge and taken across a road *via* the branches of a tree.

At the front it is found that wires are constantly getting broken, either by shell fragments or by spies. It is the duty of the telephonist to repair the line when it is found to be broken. The difficulty is to discover the broken end. To do this the operator usually runs along the line, passing the wire through his hand. On discovering the broken part a reef knot is made and pulled tightly, giving a good joint, which is then insulated. If the wire were hopelessly broken in many places, then it pays to lay a new one. In the case of important lines multiple wires are laid, these being arranged in ladder form, that is, there are two more or less parallel lines connecting the two points required to be in telephonic communication, and these parallel lines are connected at intervals by a number of other lines, which are also roughly parallel with one another. For this idea we have to thank the French.

In conclusion, the field telephonist is "a man who has to possess knowledge, skill, quickness, and bravery." It is very difficult to find suitable men for such important work, and there are not nearly enough field telephonists for the present huge British armies. The teachers of science, electricity, and physics in London should combine and offer their services for the training of field telephonists.

* *The London Daily Telegraph.*

Some Protective Activities of Organisms

How Nature Protects Its Weaker Creations

By Benjamin C. Gruenberg

One can protect himself against the rain by wearing a waterproof coat constantly; or one can put up an umbrella when the rain comes. One can protect himself against the assassin's dagger by wearing always a coat of mail, or by the clever use of a foil—or by running away. In other words, defense may result from a passive structure or condition; and it may result from an act. Let us consider some of the doings or activities of living beings that may help them in protection against their enemies or against other dangers.

We find active means of protection among the simplest animals. When the ameba is disturbed in any one of several ways, it immediately *contracts*. The effect of this contraction may be protective in several ways:

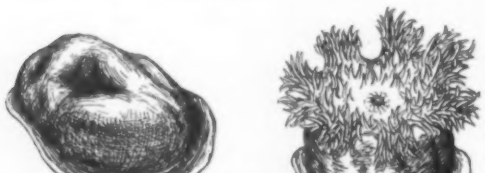


Fig. 1.—Sea Anemone, contracted and expanded.

1, it reduces the total amount of surface exposed to danger; 2, it hardens the exposed surface; 3, it withdraws the animal from the point of attack. Here are three results of this simple reaction that may presumably be of use to the animal under various conditions.

In the fall, as the ponds dry up, or as they freeze, the ameba manages to survive by producing a "cyst." This is a rounded cell with a specially thick wall. During encystment the protoplasm loses some of its water. This fact enables it to resist low temperature as well as the danger of complete drying. Under suitable conditions of moisture and temperature, the protoplasm breaks out of the cyst, and resumes activities where they were interrupted.

Contraction under stimulation is a common thing among living beings. The sea-anemone shows a remarkable amount of contraction when disturbed; in fact all the animals of this branch are extremely contractile. In Fig. 1 are shown different views of a sea anemone; from these we can see how greatly reduced the surface of the animal becomes when disturbed. In this contracted state there is very little surface exposed to the outside danger, and this surface is much harder than the usual texture of the body. The hydra and the coral polyp behave in much the same way.

Contraction of special muscles results in the closing of the shell in clams and oysters, and of the withdrawing of the body into the shell in the snails. The turtle withdraws head and legs into his "shields" and the box turtle closes the shell up even more completely, as is shown in Fig. 2.

We do not usually think of plants moving, either to get food or to escape danger. Some plants, however, can do a great deal of moving in connection with the capture of insects and other animals. Other plants are capable of movement when disturbed. "The sensitive plant" (Fig. 3), quickly doubles up its leaflets and drops the leaves when disturbed by a slight jar or quick touch. The "use" of this movement has been discussed by many observers and thinkers; but it is not necessary for us to assume that the movement is of any real value to the plant. It is true that in the new position the leaf exposes less surface. Thus, during rain, the plant sheds the water better, with the leaves in this position. But hundreds of plants with similar leaves have no difficulty about shedding rain without being so sensitive. Many plants (clover, oxalis, and others), drop their leaflets in the dark, in a few minutes. But we can conceive no advantage that this movement can give to the plant. It is possible that in the clover, etc., the drooping of the leaf is the direct result of reduced transpiration; but that does not give the plant any advantage. It is very likely that the sensitive plant is simply more sensitive than any of its relatives (the bean family), many of which are sensitive in the same way, but not in the same degree. We can see how the closing up of the armadillo or of the pill bug can protect the organism (Fig. 4); but we must not suppose that every "closing up" is necessarily of advantage to the organism.

To elude the vision of the enemy must be of real advantage to any animal. It is therefore natural for people to assume that the color changes of the chameleon must be of protective value to him and that therefore they are caused by the color of the surroundings. The true chameleon is a native of Africa, and the American

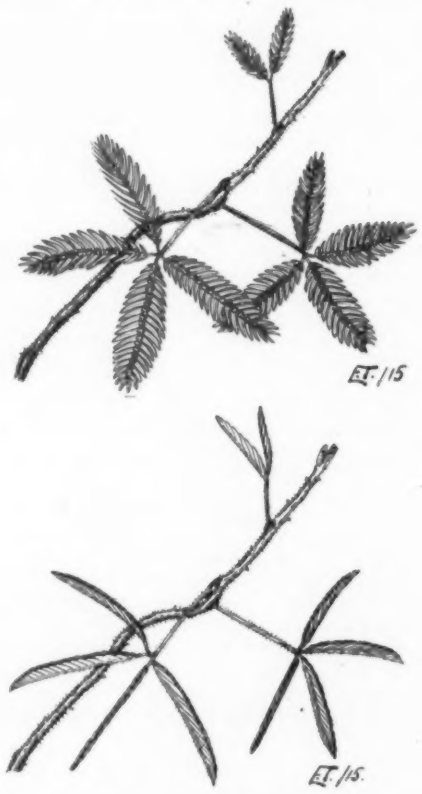


Fig. 3.—Mimosa, or sensitive plant. Leaves expanded and contracted.

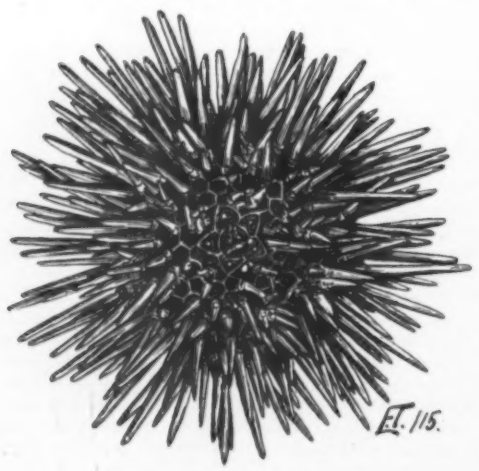


Fig. 6.—Sea Urchin, life size.

chameleon or green lizard quickly change their color through a wide range of shades, from bright green to rather dull brown. These changes are brought about by the contraction or expansion of the various parts of the skin, containing different pigments. Careful experiments show that the color changes are produced by a response to temperature changes, or by the intensity of the illumination, rather than by the color of the background. That these changes are protective may nevertheless be true, since to a large extent the amount of light or heat in a given situation may correspond to the colors. This possibility is supported by the curious fact that while the *Anolis* quickly changes color to match that of a natural background, it does not respond to the color of a background colored with aniline dyes.

Many animals belonging to different classes are just as sensitive to the colors of the surroundings, and respond by a change of body color. Among these are species of reptiles other than the "chameleons," amphibians, like the tree toad and the leopard frog, many fishes and mollusks of the cuttlefish family. Experiments with many fishes show that the change in color can in no way be interpreted as "voluntary," at least in certain species. For example, in some fish the color changes take place just the same after the animal has been blinded. Or a quick slap will produce the same effect as a rapid change in the temperature of the water, or the passing of a shadow. In some fish the color changes are produced by simply shaking a stick in front of the fish. In many situations, however, these color changes may be protective, even though they are not necessarily protective adaptations in all cases.

Another way in which an animal becomes invisible to its enemies is illustrated by the cuttlefish, which ejects a dark fluid into the water when it is pursued. This

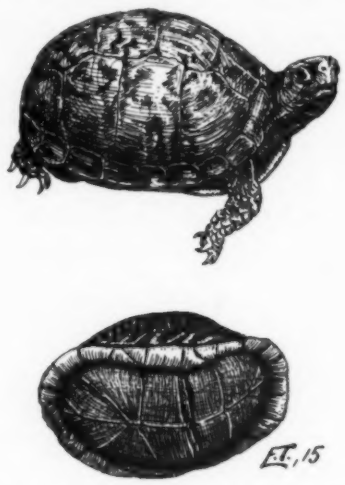


Fig. 2.—Box Turtle. Open and closed.

"ink-bag" trick clouds the water and thus enables the animal to escape from its pursuer.

Like the hiding of chickens against a fence or hedge when they are agitated, and like the "death feigning" of many insects, of the opossum, the horned toad and other animals, the discharge of the ink by the cuttlefish is the direct result of a general disturbance, rather than a purposeful act on the part of the animal. There is protection against danger for the time being, but the act is not thought out. We call such automatic acts of animals "instinctive" but that does not help us very much in trying to understand how they come to be a part of the animal's inherited equipment. All we can say for the present is that of all the possible instincts that a species of animals might have, the harmful ones would have killed the ancestors off long ago, so that on the whole the instincts we can observe are either helpful or not very injurious.

The instinct for finding a shelter is very marked in many animals of nearly all classes. In many worms we may observe a strong tendency to crawl into cracks or angles. There are certain worms that are so persistent in this trait, that if two of them are placed in opposite ends of a glass tube they will approach each other and keep on driving forward until they have worn their heads off; the contact of the body against the hard walls stimulates them to move forward, and they don't know enough to stop when they have gone far enough. A more remarkable home-finding instinct is that shown by the "hermit crab," which makes itself at home in the discarded shells of snails. As the animal grows larger, it abandons one shell and finds another. With this instinct we may compare that of the higher animals that dwell in caves or other ready-made openings that they find. A step beyond this type of protection is the instinct to make a home. When the earth-worm burrows into the ground, it thus escapes the birds and other enemies; but the burrowing is essentially a process of food getting, for the animal swallows the dirt as it digs

Fig. 4.—Armadillo. Contracted and normal.

Fig. 5.—European hedge hog. Bristling.

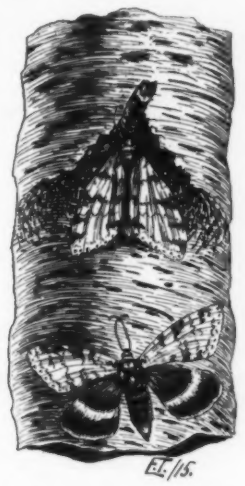


Fig. 7.—Underwing moth.

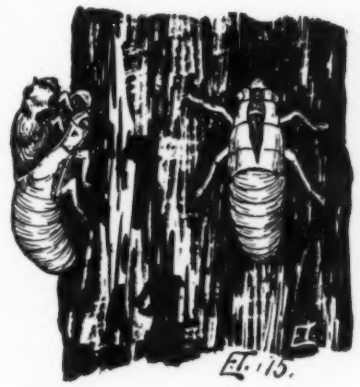


Fig. 8.—Cicada. Molting. Life size.

along, and absorbs from it organic material left by decaying plant and animal matter. In the same way do larvæ of various insects and many beetles escape their enemies by boring into trees. It is often very difficult to make a sharp distinction between a process that is primarily related to food getting and one that is primarily related to protection. And, indeed, we do not need to seek for such distinctions in all cases, for the life of the organism is a whole; it includes the feeding as well as the avoidance of being used as food, and in some circumstances a simple life will cover all the necessities by a few acts. Thus a tape-worm, living in the intestines of a child, gets food and is at the same time protected. We do not need to say that it lives in the intestines because that is a safe place; if we say how and where it lives, we have covered all there is to say on the subject.

With many animals the boring or burrowing is related altogether to protection, as with animals that bore into rocks. The piddock grinds its way into a rock, growing larger as it digs deeper, so that in the end it is completely imprisoned. From a human point of view, safety would seem to be purchased here at the high price of liberty. But from the piddock's point of view, this trick of boring into the rock probably causes no ill feeling; there is safety and there is the possibility of getting food as well, for the long siphon projects into the ocean and a constant current of water brings oxygen and food, and carries off wastes and reproductive cells.

When we come to the highest animals of the branch Arthropoda, the insects, and the highest animals of the backboned branch, birds and mammals, we find very complex activities related to the making of homes. The solitary wasp goes no further than burying a few insects that may serve as food for the young; the social wasps and hornets, like the related bees and ants, build very elaborate homes out of wax and earth and "paper" which they make from wood pulp and other materials. These homes are protections not only against possible enemies, but against changes in the weather as well; and they serve not only for the protection of those who build them, but for the whole colony, including the helpless young and the eggs.

Nest building among the birds involves complex instincts, and possibly in some cases a degree of real intelligence, that is to say, the ability to use experience. From the crude whisp of the grouse, or the simple mud heap of the flamingo to the delicate and skillful work of the tailor bird, we find a long series of nests of many degrees of complexity in structure. But with the exception of nests made in hollows, like that of the woodpeckers, whatever protection they furnish is almost exclusively for the young.

Indeed, we may say that the making of shelter among the higher animals is closely related to the protection of the young, or of a group rather than to the protection of the individual. This is seen in the constructions of such animals as the beaver or of the "prairie dog," or in the hutch of the rabbit, the diggings of a mole and the "nest" of the mouse.

A special structure, with instincts related to its use in the protection of the young is shown by the "marsupials," which include the kangaroos, wombats and related animals of Australia, and the opossums of this continent. The pouch holds the young until they are able to care for themselves. We may compare this method of protecting the young with the habit of the female lobster; the eggs, as they are discharged from the body, cling to the abdominal "swimmerets" by means of a sticky fluid. As the young hatch out, they attach themselves to the swimmerets by means of their claws, and they remain attached until they are sufficiently developed to find their way about with comparative safety.

Beginning with the ameba that withdraws its "false feet" from a point of disturbance, or that moves entirely away, and reaching to man himself, all animals that ar not confined or attached, protect themselves by some form of flight or escape. And with this fact is associated a wonderful series of organs of locomotion, from the false feet and cilia of the protozoa, the water feet of the starfish, the flapping movements of the scallop, the wriggling of worms, the legs and wings of insects, and so on up to the various kinds of legs and wings and fins of the back-boned animals.

It is impossible to say that organs of locomotion are primarily related to protection or that they are primarily related to food getting. At the very lowest levels of life we find the same structures and activities serving organisms in both relations. And further up we find feeding organs and locomotive organs differentiated from the same structures. Thus in the octopus the "arms" serve for moving about as well as for grasping prey. In the lobster or crayfish we find a whole series of organs having essentially the same plan of structure, but some

Fig. 9.—Kalluna. Head up and down.

of them used in relation to food getting and food holding, while others are related to walking, and some to swimming. The "jaws" of insects may also be considered specialized appendages that all have the same origin and the same fundamental structure. Moreover, the legs of some insects are used in food getting quite as much as in locomotion, while the legs of others are used in locomotion, although they do not enable the animal to escape from enemies or disturbance.

Even among the mammals we find the primates (monkeys, apes, man), using their front limbs in food getting quite as much as in locomotion, or even more.

A very interesting problem in connection with the protective movements of animals is that of migration. The migrations of common birds are more or less familiar to all of us. Those of us who live in the northern latitudes are likely to look upon bird migration as "going South in the Winter to get away from the cold"; or as going "South to get food." But if one asks why the birds ever come North, we can think of no advantage to their imgration except that of finding a breeding place for the young in a region free from the usual enemies or other obstacles. It is possible that some species migrated originally with relation to food and weather; and that other species migrate primarily in relation to possible enemies. Whatever the advantage to the species, it is curious that year after year the birds will follow the same routes, even coming out of their way many miles to go with the flock. It is probable that the older birds lead the migrations, and that the paths are kept by force of imitation. The young follow, and the older ones continue to do as they have always done; as a result, customs are established that persist even when they cease to be of greatest advantage or economy.

Migrations of fishes have also been recorded, and these seem to be related chiefly to finding safe breeding places. Some will go out into the ocean to breed, as the eel; others will spend most of their time in the ocean and come up into the rivers to breed, as the salmon.

Finally, we may consider a more positive form of protection, fighting back.

Nothing would seem to be more helpless and less offensive than the soft-bodied jellyfish; the very name suggests something even milder than a clam. But if you have ever picked up a live jelly fish, you might have thought that you had received an electric shock, or that a million needles had been shot into your hand. The skin layer of cells in the jelly fish contains a large number of special cells in which there is a fine hollow thread ending in a sharp point. The thread is coiled up ordinarily; but when the surface is disturbed, the coil suddenly straightens out, shooting the sharp needle into the surrounding space, and at the same time an acid fluid from the cell passes through the hair. The stinging sensation is probably produced by this fluid. These nettling cells are found in many species of animals related to the jelly fish, such as the hydra, sea anemone, coral polyps and the sea walnuts.

But some animals do give their enemies a real electric shock when they are disturbed, and this is no doubt of value in protecting them; the shocked animal quickly lets go, and learns to let other shockers alone.

Another way in which the organism can make itself disagreeable to an enemy, without really producing serious injury, is illustrated by the skunk, which, as everyone knows, ejects a foul-smelling liquid from a gland at the rear of the body, when it is greatly agitated.

Real fighting appears among animals that have mouths and appendages that are capable of grasping. These organs are at the same time food-getting organs. Lobsters and crabs are very pugnacious animals, or at least that is the impression they make upon the observer. It may be that as they exercise their pinchers and nippers, in response to the instinct of grasping at everything with which they come in contact, their movements simply suggest fighting to us, and that there is really nothing that corresponds to the feeling of pugnacity. Most of the molluscs (clams, oysters, scallops, etc.), depend upon their armor for defense against aggressors; some of them, however, as the octopus, are good fighters.

Among the insects, many are predatory, using their appendages in catching prey, or their mouths; but very few use these organs in fighting their enemies. The colonial insects, especially the ants, are the best examples of this mode of protection. The bees, wasps and hornets fight when they are disturbed, or when the colony is disturbed; but they fight with the "sting" which has nothing to do with food getting or with locomotion. The sting in these animals is the egg-laying organ. When a bee plunges her sting into your flesh, the sting is likely to remain there, and as the animal flies away some of the internal organs are mutilated, and the insect soon dies. This kind of self-defense certainly looks suicidal; but the advantage of the extreme method must be considered from the point of view of the whole colony, or the species. If the sacrifice of a few fighters saves a colony, or if the sacrifice of a number of individuals in each generation educates the possible enemies into letting them alone, the species will on the whole be the gainer. The sting of the scorpion is also at the hind end of the body, and is associated with poison glands.

Nearly every method of fighting enemies that can be found among the mammals can be observed among little girls and boys. Biting, pinching, scratching, beating, kicking, butting are parts of our common experience. And our common observation makes us compare these acts with the doings of dogs, monkeys, cats, horses, goats. The claws of the cat and her relatives are usually drawn in, except when the paw is about to strike. The tusks of the elephant and the walrus are exaggerated teeth. The hoofs of the horse and cow, although they do not look like claws of bears or lions, are also specialized toe nails.

The various kinds of horns of mammals are specialized skin structures. That is, they grow from parts of the skin tissue, although there may be a bony hump at the base in some of them, as in the rhinoceros. These horns are associated with the instinct to defend or to fight, and are quite independent of the food-getting organs or instincts. Thus, while the ferocity of the tiger or the dog finds expression through organs that are related to food getting, the strictly vegetarian rhinoceros or mountain sheep will fight fiercely and courageously with horns or hoofs. The branching horns of deer or elk, which are bony structures, are never used aggressively except against members of their own species, as when two males are in combat.

A less familiar form of defensive activity is that of the porcupine, which "bristles" up when disturbed or attacked, and may throw its quills a considerable distance by muscular contractions of the skin. The bristling hedgehog (Fig. 5), presents a very unattractive surface for attack.

In considering defensive activities we have used illustrations from the lives of animals. But plants are also capable of *doing* things of a protective nature. The dropping of leaves in the Autumn, while it does not involve movements like those of muscles, may properly be considered as periodic protective acts. The shedding of leaves seems to be related to the water factor as well as to the temperature factor, which we usually associate with the change of seasons. As the Autumn advances and the water in the soil becomes scarcer, transpiration is interfered with. Evaporation from the leaves, however, continues so long as there is water in the cells. If the loss of water cannot be compensated by the absorption of the roots, the live cells of the plant must suffer injury. The leaf cells are the first to be affected. The loss of the leaves prevents the complete drying up of the plant, and it also prevents the freezing of live cells.

In the plants that regularly drop their leaves in the Autumn there is formed a special layer of cells in the stalk of each leaf (and sometimes of each leaflet of a compound leaf). These cells are thin walled and turgid. Their contents break down into a mucilaginous mass, and dry up. A slight movement is now sufficient to break the fibro-vascular bundle at this point, and as the leaf is removed, the exposed surface becomes a self-healing scar.

In many plants the leaves do not drop off, but wither up. In the so-called "evergreen" plants the destruction of the cells of the leaves by freezing seems to be prevented by the presence of sugar instead of starch. The sugar in solution lowers the freezing point of the cell. This is the case with plants in the pine family.

The response of plants to special mechanical and chemical disturbances is illustrated by the formation of the so-called "insect galls." Many insects sting plants and suck juices from them for food. The mosquito is an example, and the plant lice are parasitic sometimes to a degree that is harmful. But many insects sting plants with their egg-laying organs, and deposit the eggs in the tissues of the plant. Associated with the process of egg laying there is often a secretion of some juice from the insect's body. The mechanical or chemical injury thus produced is probably very slight. But the young that hatch from the eggs deposited in the tissues of the plant begin to feed, and the injury they do is likely to be of a more serious nature. We find that many plants begin to grow rapidly about a point at which insects have laid eggs, forming casings of various shapes and structures about the mass of eggs—and eventually about the young insects. Within these "galls" the insect larvæ find a limited amount of food, and they are cut off from the rest of the plant. It is probable that by the formation of such galls many plants are really protected against serious injury, although many of the galls may simply represent a way that protoplasm behaves when injured in a certain way, rather than a useful way of behaving, since in some cases they are formed in response to an insects's food getting. It is interesting to note that the galls are always specific. Thus, on a given plant two different insects may lay their eggs; and two distinct kinds of galls will be produced. On the other hand, two insects of the same species may sting two different kinds of plants, and again two distinct kinds of galls will result. Experiments so far made have failed to discover for us just what it is in the insect's sting that determines the formation of the gall. It is probably not the mere entrance of the ovipositor, for mechanically this can be imitated, and does not result in stimulating the growth of the leaf or stem. It may be the chemical stimulation of some substance secreted by the insect; although in some cases it has been shown that this does *not* result in the formation of a gall. It may be something secreted by the developing egg; if it is, that would be a difficult matter to experiment with, but we shall never be certain until we do find out by experiment. Some galls (as the "May-apple" found on oak leaves in the Spring), have been used extensively for ink-making, on account of the large amount of tannic acid which they contain. The formation of galls is, however, an injury to the plants, and their presence indicated the presence of an undesirable insect to be exterminated or resisted.

The "organic response" illustrated by the formation of an insect gall may be compared to the behavior of the cells of the body of one of the higher animals, and especially of the white corpuscles, under the influence of various foreign bodies, such as bacteria.

When compared to other animals, man appears many ways as a rather weak and defenseless creature. His skin is very tender, compared to that of other animals of the same size, and is a very poor defense both against the weather, and against the mechanical dangers that lie in the claws and teeth of his enemies. His hairy covering is very sparse, and in some races (the whites), there is not sufficient pigment to protect the body against the sunlight. When it comes to fighting, his nails are very soft and weak, compared to those of other animals, his limbs are not so strong, and when it comes to running away, he is not very swift. Yet our ancestors have managed somehow to escape the many dangers that beset all living beings, although the proportion of those that "died young" must have been very, very high. How did they manage to do it?

A Modern Psychology of Animals.

THERE have been of late years many revolutionary changes in the domain of the natural sciences, and one of these has to do with the views held concerning the psychology of animals.

Animal psychology attained considerable importance as far back as the middle of the last century, largely through Büchner's writings. The one of his books referring especially to the subject is called "Mind in Animals," with the subtitle, "Nations and Acts of the Minor Ones." The book is still read, largely on account of the popular style and the power of romantic description of the author. It expressed the opinions held by many in its day as to the mental characteristics of animals. Darwin's researches having brought man and animal close together physically, these views were based upon the desire to close the mental gap between them. But the theories started from the wrong end, namely, from the human being. Thus, conceptions taken from the mental life of human beings were transferred to animals, the mental capacity of man was attributed to them to a greater or less degree, and the endeavor was made to discover in every animal a disguised human being. This indeed may be said to be the opinion of various persons to-day. In the work mentioned above, Büchner quoted passages from F. M. Trögel's "Talks on the Psychology of Animals," which express the state of mind of those holding such theories better than any description. One of these quoted passages says: "The more man observes himself . . . the more he is penetrated by the great truth that animals, like man, think, will, and feel . . . and he is astonished to find in animals all those things which he has just discovered in the most secret corners of the human heart and mind. Intelligence and stupidity, good and bad taste, kindness of heart and malice, constancy and frivolity, courage and boastfulness, gratitude and ingratitude, wastefulness and miserliness, hope and despair, sorrow and joyousness . . . rise into view from the wide domain of animal life, and everywhere the astounded observer sees the accurate copy of our entire social, industrial, artistic, scientific, and political life."

So there is attributed to the animal offhand not merely intelligent action for a conscious end, but also the rich life of feeling, and the perception of ethical principles developed by human civilization. Büchner's book contains examples to prove these psychical qualities of animals, the larger part resting on inaccurate observation, largely made by untrained observers, or on false interpretation of correct observations.

As is easy to suppose, research soon revolted from this kind of animal psychology, and turned to the more exact investigations of anatomy and physiology. In this way the ground was prepared for a method of psychology based on experiment. While biology, and especially œcology, are occupied with the reciprocal influence of the animal and its surroundings, the new animal psychology endeavors, first of all, to determine the reactions of the animal from the different stimuli. The exact determination and analysis of all the individual stimuli would enable us to settle positively the method of action of an animal. Such researches touch the boundaries of three scientific provinces, namely, œcology, which settles the biological basis in showing the animal in its reciprocal relations to the surrounding world; physiology, which makes plain the mechanism of reaction; and lastly, psychology.

A late number of the German journal *Prometheus* contained an interesting article on animal psychology written by Dr. W. Schmidt, an assistant at the zoological institute of the University of Jena. After commenting on Büchner and his views, as given above, and the necessity of more scientific research, he continues the discussion by saying: "The new psychology of animals, also called the behavior of animals by American writers, seeks to analyze the phenomena and to determine the physiological conditions from which they spring. This, however, in no way means that all the actions of animals can be explained as purely mechanical effects of stimuli. This is what Loeb tried to prove in his theory of tropism, which makes animals the puppets of nature. Were animals nothing more than such, then the effect connected with each stimulus must mechanically follow it. Research, though, has shown that this is not always the case. On the contrary, we see the most varied modifications appear in the method of action of an animal. These are conditioned mainly on the history of an animal. It is plain that animals, at least the higher ones, can learn, that is, can make use of experience, as investigation shows. Bethe took a crab, *Carcinus mænas*, and put it in a box on the side toward the water. The half of this open side was covered by a pane of glass, so that only the other half gave unhindered egress. In trying to reach the water, the crab first tried in equal proportion the open way and the one covered with glass. After twenty attempts the crab chose the right path in 75 per cent, after sixty attempts in 90 per cent. After four hundred trials the crab only made 2 per cent of failures. It put its experience to use. These experiences, naturally, cannot overthrow the method of action of an animal, but can modify it in the most varied way. It frequently happens that the basis of reaction is simplified by frequent repetitions of the same stimulus, that is, the chain of successive reactions is reduced. Still, the axiom holds that every action of an animal is the function of stimulus, method of action, and history.

As the organization grows more complicated, the difficulty of research increases. For the finer the differentiation of an animal, the more numerous and more highly organized the afferent impulses following the stimuli; the reactions are also more complicated and the individual history becomes more important.

Thus, it is clear that the behavior of the lower animals must first be investigated. Research as to the characteristics of lower animals, based upon experiment, has made great advance of late years, and the method of action of many known animals has been discovered. Investigations intended to place the mental qualities of animals upon a physiological basis have resulted in fairly simple explanations of various phenomena not previously comprehended. In this way it was discovered that the recognition and greeting of one another by ants of the same stock rests upon the nest-odor of each nest and kind of ant. When ants were bathed in alcohol and the nest-odor thus removed, such ants were attacked by their nest comrades, that is, treated as enemies, until the nest-odor was again perceptible and the creatures were once more treated as comrades by renewed touching with the antennæ below the eyes, which are the organs of the chemical sense. The well-known ability of ants to make a straight path from the nest to their goal receives the explanation that these straight roads are the result of many crooked paths. As ants always return the same way they came, being guided by the odor of the nest, they gradually cut down large curves. Thus, the shortest connecting line must finally be made between the starting point and the goal. Dr. Schmidt thinks that these results show the value of the exact animal psychology in biological questions.

How to Sharpen Razors and Pocket Knives

CUTLERS have certain rules for sharpening razors, pocket knives, etc. "A razor," said one of the craft, "must be laid flat on the hone, because it is hollow ground and requires a fine edge. But a pocket knife requires a stiff edge, and the moment you lay it flat on a stone, so as to touch the polished side, you injure the edge. It must be held at an angle of twenty to twenty-five degrees and have an edge similar to a chisel."

Commercial Conditions in South America*

Extensive Engineering Improvements Greatly Needed Everywhere

By A. B. Lueder

So much has appeared lately in the papers and magazines regarding South America and South American resources that it may be that readers will be interested in observations noted in a visit to Chile, Peru and Bolivia.

The West Coast of South America as seen from the deck of a vessel is not very inviting. A rocky shore line with a very narrow plateau running up to the foothills, and back of these foothills in the distance the higher mountains, is characteristic of the coast from Peru south. Everywhere a lack of vegetation, no trees nor shrubs, nothing but a yellowish sand with perhaps enough nitrate in places to make it look white. But the sea is glorious and the climate cannot be excelled. The Antarctic current coming up along this coast tempers the climate in summer and winter. Storms are few and generally not heavy, their only effect seeming to be to increase the size of the already large swells on the Pacific Ocean. It seldom rains and fogs are infrequent.

The harbors of the large cities of Peru and Chile are poor, being almost open roadsteads. Callao has a mole to which the vessels tie up, but I understand the vessels must put to sea in storms from the north. Iquique, Mollendo, Antofagasta and Valparaiso are practically the same. Coquimbo has a very well protected harbor. There are several fairly well protected harbors on the coast but for political reasons in some cases the towns have not been built at the good harbors.

Within the next few years, if the west coast of South America is to do the trade the world seems expecting it to do, there will have to be a great increase in shipping facilities. At the present time practically all goods as well as passengers are transferred in the harbor and taken ashore in boats. This is inconvenient enough for passengers, especially at some ports where the swell always runs high and where, if there has been a storm perhaps 1,000 miles off the coast, something you may not have known about, the transfer is a hair raising process to the uninitiated. It is dangerous even with the help of expert boatmen to be put into a tub, slung up in the air and landed right side up in a small boat where the oarsmen are doing their best to keep underneath the tub and keep from being dashed to pieces against the side of the vessel. In loading or unloading cattle and horses it is both cruel and dangerous, the cattle often being dashed against the side of the vessel, breaking legs and sometimes killing the animals.

As to goods, this is one of the reasons why they should be well packed for South American trade. They are unloaded in slings from the hold of the vessel, a ton or two at a time, hoisted out, dropped into the boat and unloaded from the sling, simply by turning loose one corner of the sling and pulling it out by the donkey winch. You can readily realize the effect upon bulky freight flimsily packed, especially with the ship rolling and the launch jumping like a bucking horse. Heavy boxes of canned goods roll down upon cases of glassware and other fragile ware with a perfectly obvious result.

The average South American stevedore can teach the Yankee baggage smasher a great many new wrinkles.

The troubles of the goods are not over when they are in the launch, for they have to be unloaded from this bucking, pitching launch, swung ashore, taken to warehouses or more often piled in the public square until the custom officials can do what they think is their duty. Then, if the goods are destined for a minor port they have to go back on board the launch, back on board the vessel taking them to the port of minor, later to be unloaded at their destination. If they go into the interior direct from the port of major, their fate is little better, as after they have passed the customs they are loaded on trains and their handling is much the same as in this country. But it is the poor port of minor's goods that receive the rough usage. This having to unload the goods in the major ports to pass the customs is a most aggravating affair to a shipper at a minor port. Goods are liable to lie on the ground in the open for weeks, meanwhile you have to supply watchmen and covers. If a rain-storm does come, which luckily is seldom, it is liable to prove disastrous, especially with flour. I have seen thousands of bags of flour lying in the open in various ports, and in one case I saw a large quantity ruined by one of the infrequent rains of northern Chile.

The inspection by the custom officers is also annoying, your word is not taken, cases are required to be opened, frequently to the detriment of the contents, and with a probability that samples will have to be passed around among the custom officers. This is a considerable burden, especially with small shipments.

The classification of shipments is a most important thing to keep in mind when goods are shipped to South America. The tariffs of Chile and Peru are very peculiar. In Chile the value of the goods is not taken in the port of shipment, but an assessed value per unit is put upon them and the tariff is made up therefrom. This frequently leads to absurd tariffs. For instance, I paid a great deal more in tariff on 100 rolls of tar paper than it cost in New York, and it amounted to more than the tariff on the largest hoisting engine we had. Another amusing discrimination was on boilers. Locomotives have a tariff of 5 per cent upon a valuation per pound. This includes boilers and all parts of the engine. We had some boilers of the locomotive type go through for 5 per cent as they were invoiced as locomotive boilers although we paid the full 40 per cent on others of exactly the same type, which were invoiced simply as boilers.

The reason for the backwardness in improvements for handling imports in countries which import practically everything, is the political power of the boatmen and stevedores. They are a political power with which no Chilean or Peruvian politician wishes to be at odds, and laws which would tend in any way to cut off the revenue of those men are most difficult of passage. Hence, the lack of port improvements and the obsolete methods of handling freight. In fact, at most ports laws are in force which favor the boatmen as much as possible. In Valparaiso, although a friend may come alongside of your vessel and take you off, he cannot take off your baggage. This must go ashore in a registered boatman's boat and be paid for, at a stipulated tariff.

Most of the harbors are susceptible of improvements at what to South Americans is yet a prohibitive price. But the next few years is certain to see a great many of them carried out. What with the Guggenheim Company, operating at Antofagasta and Tocapilla, the Bethlehem Steel Company at Cruz Grande and Coquimbo, the Standard Oil Company in the Peruvian oil fields, there is sure to be a great deal of money expended and pressure brought for important changes. It is altogether likely the South Americans will see the value and necessity for these changes in the near future. Signs of this are seen in the increasing number of motor boats for pulling the lighters in to shore. The motors were opposed, but are now becoming more and more common in the towing of boats.

The engineering improvements for South America are not all in the ports, the towns need sewers, and need them badly, as you readily realize by walking through the streets. They need paved streets. There are very few decent highways in South America outside of the large cities. Lima, Valparaiso and Santiago have paved streets but not a great many. Antofagasta was letting some contracts for roads this spring. Antofagasta was agitating for sewers, as also were some towns in Bolivia.

Mining is, of course, the great business of the west coast. Mines seem to be everywhere. Gold, silver, bismuth, copper, tin, lead, antimony, arsenic, you can have your choice. I should say from the mines I saw that they are capable of many improvements. Good returns were being made at a couple of old mines by fellows with modern methods and machinery working over old tailings.

As for business opportunities, they are many, but I should not advise anyone to go down there unless he had a good knowledge of the Spanish language and some money to invest. If he were to go it should be with the idea of first spending a couple of years studying the language and the people, and becoming conversant with their ways of doing business.

There is no use of a young American going down there to look for work without knowing the language. In the first place practically all the business is done by English and German houses. They do not want young Americans, they want their own countrymen, first because they will work cheaper, and second because they do not believe in training up competitors. Even so-called American firms use practically all English or German help. I believe thoroughly that our battle for South American trade is going to be a defeat simply for the reason that the South American houses are run by English or German heads and manned by their countrymen, and are not going to help us in any way but will buy from their own countries as soon as they can do so. It certainly seems as if the large American concerns would see the advisability of training up corps of young Americans. They have not done it until lately, when the European labor sources have been cut off. America's hope lies in having an army of young fellows trained by the time the war is over so that they can fight for the South American trade on a somewhat equal basis.

Some concerns are training a few men, but the heads of many of the sales offices are foreigners. The reason for this in the past is perfectly obvious. Spanish speaking and Spanish trained young Americans were not available to fill the larger positions. It is going to be the case in the future unless in some way Americans are trained in the South American trade.

Railroad building in South America is sure to increase as soon as the governments get over the effects of the war, and with the increased facilities for trade brought about by the Panama Canal, these governments should prosper in the future. Practically all the railroads on the west coast are owned by English syndicates or the government. They are being brought to the standard gauge as fast as possible. They were built of various gauges.

In Bolivia the railroad shops are quite complete. The government of Chile is now closing negotiations in this country for railroad shops and equipment to cost upward of two millions.

Electrical projects on the west coast except in southern Chile are not going to be common or likely to pay. The streams are not large enough and the demand for power is not there. Should some commerical electrical method of smelting tin be devised, there certainly is a field for it in Bolivia.

Agriculturally the west coast countries have done nothing as yet and they do not produce half of what they consume. In the near future great irrigation projects are going to be put forth. I know now of concessions for two large irrigation schemes, one in Chile and one in Peru. Bolivia and Peru have millions of acres of virgin soil with the best of climate, and capable of producing all the products of the tropics and temperate zone. The great necessity is capital and transportation.

In fact, what South America needs is capital and brains. There is no use of one without the other. The governments of Bolivia and Chile are fairly stable, that of Peru is unstable, still concessions are generally not molested and those of the subjects of England and Germany are very much respected. Americans have few concessions as yet and one cannot say whether they will be respected or not, but the average South American has a profound respect for the source of his cash, so that with the American money now being poured into South America there should be an increase in respect for Uncle Sam.

As to the east coast of South America, I am not personally familiar with it, but was told by men on the west coast who were familiar with the east coast, that before the European war commenced, business opportunities on that coast were better than in the west. The war stopped practically everything in South America mining and agricultural with the natural results upon all trade. I understand now that since the rise in prices and the increased safety in shipping mining is booming, and as I have seen notices of inquiries for 80 grain elevators and 20,000 houses for Argentine, it certainly looks as if they were becoming prosperous again, or at least looking to the United States to finance their construction operations. This matter of finance is of course the great stumbling block to the United States claim to South American trade. The United States as yet have no banking exchange with South American countries and until we do have such exchange with all the credit information which goes with successful banking operations, we can hope for little South American trade. Unless such banking facilities are put into operation at once the United States is going to lose a great part of its advantage caused by the European war.

Engineers who prepare themselves by learning to speak Spanish and possibly by a few months travel in South America studying the peoples and their ways of doing business, will be in a position to take advantage of the opportunities which are sure to arise in South America when the European war is over, if not before that time.

*The Cornell Civil Engineer.

Sugar as a Photographic Restrainer

A WRITER in *Comptes Rendus* states that sugar has a decided restraining effect when added to a photographic developer, and possesses some advantages over potassium bromide. He states that the time of development of a normal metol-hydroquinone developer of 100 cubic centimeters was increased from 5 seconds to 5 minutes by the addition of 60 grammes of sugar without fogging the clear parts of the plate or injuring the quality of the black deposit. Smaller quantities of sugar were found to produce correspondingly smaller increments in the time of development.

The village of Inden on the new electric line from Leuk to Leukerbad.

The Leuk-Leukerbad Railway

A Scenic Line in the Bernese Alps

ANOTHER heretofore sequestered valley in the canton of Valais has now been brought into regular railroad communication with the outer world, i. e., the Dala Valley, with one of the oldest watering places in Switzerland, Leukerbad or Loueche-les-Bains, situated at the foot of the celebrated Gemmi Pass. The thermal springs of Leuk, with 93 to 123 degrees of Fahrenheit, were well known to the Romans, and are in these present days justly famous for their beneficial qualities in cases of rheumatism and such like complaints.

The construction of the railway, for which concessions had been obtained in 1899 and 1902, was finally begun in 1912, and the official inauguration which had been planned for last year took place on July 3rd last, the European war making this delay necessary.

It is a narrow-gage electric line with a total length of 6½ miles. About 3¾ miles are of the traction and the rest of the rack-and-pinion system. The minimum radius is 30 meters and the maximum gradient is 16 per cent. Use has been made of the old post road for a distance of 2½ miles. Noteworthy technical features of the railway are three tunnels and three bridges of average length.

The railway starts from the station Leuk-Susten on the Simplon line of the Swiss Federal Railroads system and immediately crosses the Rhone on a newly constructed bridge. Passing the little city of Leuk, which is situated on a vine-clad hillside, the line begins to ascend the valley of the Dala, high above the river, thus affording a splendid view of the Valasian Alps. Stopping places have been created for the two hamlets of Albinnen and Rumeling and a regular station has been allotted to the village of Inden.

After Inden the line follows the old post road high above the Dala gorge; Russengraben, a third stopping place, is passed, and in another fifteen minutes the train reaches the Baths of Leuk. While the trip by diligence required four hours, the railway covers the same distance in 1 hour and 6 minutes.

Economy in Food*

Wartime Measures That Are Interesting Europe

By A. K. Chalmers, M.D. Glasg., F.F.P.S. Glasg., D.P.H. Cantab, Medical Officer of Health Glasgow

ECONOMY in food during war is happily an unusual theme for discussion by this association. Its importance under present circumstances is due to the fact that food forms a very considerable item in our national expenditure, and the urgent need for restricting expenditure in all directions save one is being urged from many platforms.

Economy in food has two sides: it may mean better selection in what we buy, or better use of what we have. The poor, I think, frequently err in the first direction, the wealthy just as frequently in the second, and there is waste in both. I propose asking whether and how this may be avoided. Whether we agree as to the answer is of less importance than that we should realize how important to the national finance and national well-being economy in food may become. Take two illustrations.

For some years past the quantity of butcher meat imported from abroad has ceased to increase at its former rate, and the Board of Agriculture has told us that the shortage has been met by increased home production.[1] More recently the same board has issued a series of leaflets containing suggestions for the formation of village food societies, with the object of increasing the production and utilization of certain foodstuffs, including wild fruit. Economic forces alone determined the former movement; war is the declared reason for the village schemes. It is well to remember that the first indication that certain sources of food were not inexhaustible came during a time of peace and great prosperity; that even without war and possibly within a generation we should in all likelihood have been compelled to consider what revision of our sources of food-supply was necessary to avert shortage, and that continued shortage in the nitrogenous elements of food ultimately means starvation. Within limits the other principal elements of food—the fats, starches, and sugars—may replace each other in nutrition, but none of them can for chemical reasons produce or replace the nitrogenous.

Under peace conditions we pay, it is stated, something like three hundred millions annually as the price of food imported from abroad. Whether we have been wise in preferring this lavish expenditure to the neglect of home sources of food-supply is a question for the economist. At the moment, and for our present purpose, it will be more useful to consider whether we are making the best of what we have. Take a simple illustration.

PHYSIOLOGICAL ECONOMY IN NUTRITION.

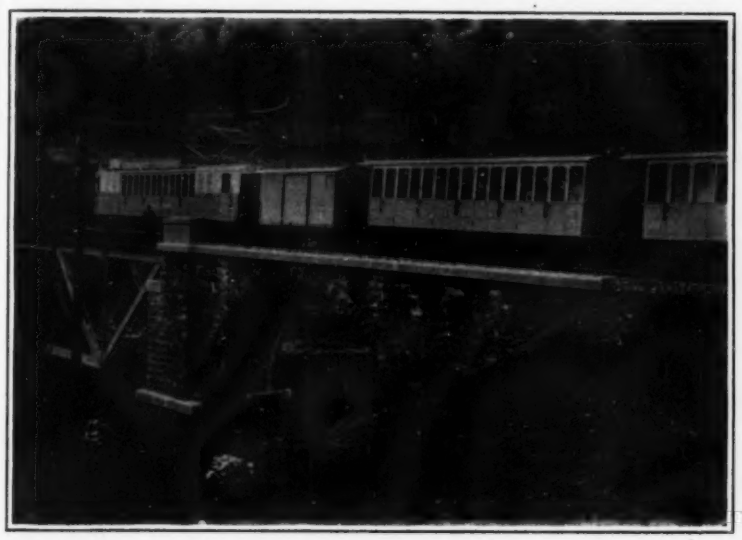
The manufacturer whose chimney pollutes the atmosphere with the unconsumed products of combustion is accused of economic waste because he is discharging into space material that might have become a source of heat. His supply of fuel has not been related in time and quantity to the temperature and volume of the air which he can supply for combustion. To anticipate a parallel, the metabolism of his furnace is at fault. In other words, the relation between the supply of fuel and the means of consuming it has not been properly adjusted. He fails to get full advantage of the heat his fuel contains, and the most obvious result is black smoke. There is a certain parallel between this and the physiological economy of nutrition. The body requires a certain amount of food varying in character and for different purposes. In early life the organs must be built up; at all times the body heat must be maintained; work must be done; tissue waste must be made good, and it is possible to translate the combined demand which these make into the equivalent energy which may be obtained from a given quantity of food. But defective food metabolism has a different result from the corresponding defect in the boiler furnace. There is no convenient and easy exit for the unconsumed products such as the chimney affords.

One end of the scale of nutrition is controlled by the power of the body to digest or assimilate or convert into its own structure the nutritive material which it obtains from food; the other by its power of disposing of the waste material which every form of bodily energy produces. Between them lies the whole field of metabolism; the building up of the body from the food elements, and the breaking down of the tissue cells in heat and other forms of energy, and on the balancing of these two healthy living depends. If the supply of food for building up is restricted stunted growth results or energy fails; if it is continuously in excess of what is required for physiological needs disease results, and the high-tension arteries which figure so largely in modern diseases are probably more often the result of persistent eating to excess, combined with sedentary life, than of business worries.

Food metabolism, then, represents the nexus between the intake of food on the one hand and the demand for heat and energy on the other, and its perversion implies disease. In peace time the amount and variety of food in which a man may indulge is limited only by his dietary

* A paper read at the Forty-first Annual Congress of the Incorporated Sanitary Association of Scotland.

[1] Agricultural Statistics, 1913, Cd. 7551, p. 286.



An electric train on the Leukerbad line.

A view of Leuk, the starting point of the new railway.

'aste and his ability to purchase. If he chooses he may overeat, and no one suffers save himself. In time of famine or siege everyone would be rationed, and the only possible standard of supply would be the physiological requirements of the system—so much nitrogenous food, so much starchy food or cereals, so much fat, etc. Variations dependent on the ability to purchase would cease, and the need of a household would be the measure of its supply. The standard is an ideal one and almost unattainable save under the pressure of necessity, but the difference between the siege ration and unregulated indulgence in food represents something which includes one form of waste which may be called physiological, because it implies the consumption of food much in excess of the amount necessary.

Another form of waste, equally preventable, is wholly economic in the strictest sense. It prevails in the household, the hotel, the restaurant, the club—wherever, indeed, food is prepared and consumed. It is largely a woman's question. It is the waste of surplus food; the failure to take out of the last ounce all the energy it contains. Bread is probably the outstanding illustration.

Still a third form of waste at the present time is the waste of fashion in food. It was in this connection that Hutchison insisted on the need for an economic test for food. We pay for fashion and taste in food as we pay for cut and style in dress. In neither case does the amount paid represent the value of the nourishment or protection obtained. Salmon, turbot, and eel, herring, mackerel, and mullet are rich in fat as well as proteid. Cod and haddock, although poor in fat, have almost as much proteid as halibut, which costs about twice the price of cod. The calorie value per pound of herring and mackerel is equal to about two thirds that of salmon; while the absence of fat in cod and haddock may easily be corrected by the addition of butter or margarine in sauce.

Remember the conditions of the struggle. We are told that this is a war of exhaustion—exhaustion of resources. t has been stated recently that half the national income is being spent thereon. What is unnecessarily spent on food is lost to munitions.

A STANDARD DIETARY.

It is difficult to speak of a standard dietary without spreading a net for the unwary. The fault is not in the standard, but in the use made of it. The potential energy or value in calories[2] of a given quantity of mixed food is readily ascertained, but when transformed into a standard dietary for daily use, difficulties begin.

It is said that the actor Kean "used to adapt the kind of meat he ate to the part he had to play, choosing pork for tyrants, beef for murderers, and mutton for lovers." I suppose this is an exaggeration, but it embodies, at least, a common experience. Monotony in diet is fatal to the enjoyment of it. There must be variety, and dietary scales usually fail in this. Most reforms in the dietary scales of institutions have had the introduction of variety as one of their main objects.

Another pit digged for the unwary by the standard diet is the mechanical use of it in the calculation of dietary scales. Weight, age, sex, exposure, work, all have part in the construction of a standard diet, but when this has been ascertained and its weight multiplied into the number of persons to be fed, waste in one or other constituent invariably, I think, results. The wastage in bread and butcher meat we hear so much of at present results from this. A standard diet is useful for revising and correcting dietary scales, but its mechanical application leads to extravagance.

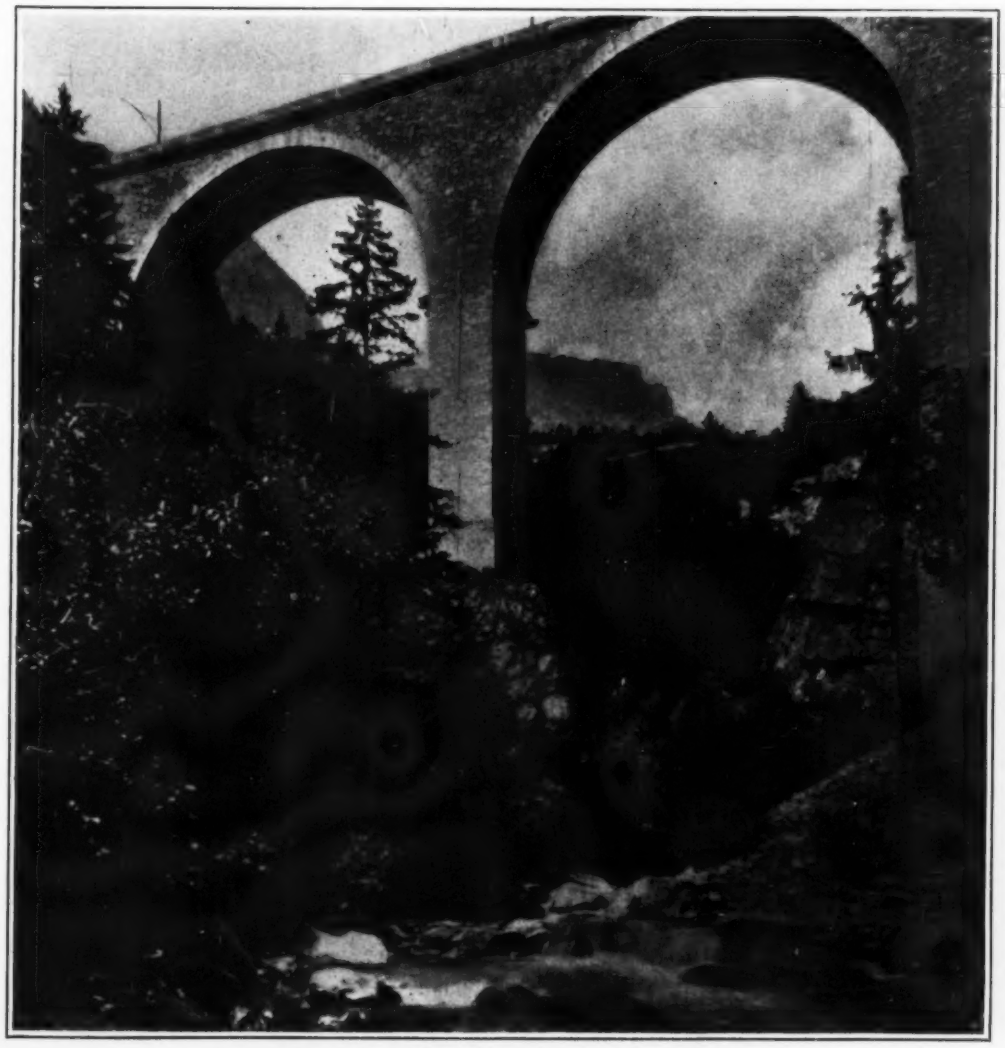
The physiological classification of food-stuffs is well known. The growth or body builders are the foods containing nitrogen,[1] the heat and energy group includes the fats, starches, and sugars. We may be said to live on the former and work on the latter. Leaving aside the vegetable foods, which are valuable and necessary mainly as a source of mineral salts, the quantity of the principal constituents of food consumed by men doing an average amount of labor may thus be stated from the average of many observations in Europe and America:

	Weight in ounces.	Grammes (approximately).	Nitrogen ratio.	Calories.
Protein.....	4.51	128	1.0	524 (nitrogenous).
Fat.....	2.32	66	0.5	612 non-nitrogenous.
Carbohydrates....	18.32	519	4.0	2139 non-nitrogenous.
Total.....	25.15	713	...	3275

[1] The flesh of animals, the white of egg, much of the solids left in milk after creaming, and varying proportions of most cereals are common illustrations.

Food is not, of course, bought under any of these categories, but they will help us to understand the nutritive value of the articles which contain them. Observe, however, that the nutritive ratio—i. e., the proportion of the proteid to the non-nitrogenous food—is one to fully five, and remember that, while the fats and starches are to some extent interchangeable in function, neither can replace the nitrogenous. By weight the relation between the proteids and the other constituents is 1 to 0.5 of fats and 4 of carbo-hydrates, but owing to the greater heat value of equivalent weights of fat its calorie ratio per 100 from nitrogenous sources is 117. Healthy dietary demands that this proportion be maintained during adult life at least. Every inquiry into the dietary of the poor has disclosed a tendency to excess of carbohydrates. During the period of growth and convalescence from illness the proportion of nitrogenous food should be somewhat greater; in old age less. No single article of food, however, contains these constituents in the proportion required, and hence the necessity for a mixed dietary.

Here are some illustrations of nutritive values of articles in daily use, calculated as calories or heat units



The picturesque viaduct of Rumeling over the river Dala.

[2] In physics the amount of heat required to raise the temperature of a given volume of water 1 deg. Cent.

per pound weight unless otherwise stated.

1 Pound.	Calories derived from—			Total calories.	Current price in pence.
	Proteid.	Fats.	Carbohydrates.		
Meat (uncooked not much fat)	372	147	....	519	17
Bread	149	63	910	1122	2
Cheese	614	1012	....	1626	10
Milk (1 pint)	97	193	121	411	2½ per pint.
Potatoes	28	4	426	459	½
Herring (3)	362	299	....	661	12 per doz.
1 egg (weighs 2 oz.)	27	51	....	78	18 " "
Butter, 1 oz.	...	236	....	236	19 " lb.
Margarine, 1 oz.					4 " "
Oatmeal	242	253	1208	1703	2½ " "
Barley meal	236	84	1320	1640	2¼ " "
Lentils	429	84	1088	1601	4 " "
Ratio of calories in standard diet	100	117	406	....	....

These are the potential calorie values of several foods, but it must be remembered that a certain proportion of most of them is not absorbed during digestion, so that the actual food value is almost always less than the calorie equivalent. This loss may be stated at about 10 per cent overhead. The starches, as a rule, lose least, the fats a little more, and the proteids a still larger proportion, which is more marked in the vegetable proteids than in those from animal sources. This is in part due to the cellulose present in vegetables, and their cooking requires more care.

Carbohydrates (the starches and sugars) cost little, the fat of margarine has the same dietetic value as that of butter and costs one third of the price at present. Oatmeal is rich in fat as well as proteid, three good herrings have more fat than one pound of lean butcher meat and cost about one sixth of the price, unless meat is bought as "odd pieces."

The problem of economic dietary is the selection of the source of the nitrogenous element. One pound of lentils, costing about 4 pence, will yield more proteid than a pound of butcher meat at 1 shilling 5 pence, and in addition almost one half of the daily calorie value required from the carbohydrates. They are deficient in fat, however. For 100 proteid calories obtained from butcher meat in the foregoing table the price is 4½ pence; for a similar quantity from cheese rather more than 1½ pence; from oatmeal fully 1 pence; from lentils rather less than 1 pence; and from herrings about ¾ pence. Taken generally and for equal quantities, this confirms the statement that animal proteid is about four times dearer than vegetable. There is, however, some risk of exaggerating the difficulty, and a sudden and violent alteration in food customs is neither necessary nor desirable.

More important, indeed, is the need for reducing the wastage in surplus food which takes place, I think, among all classes. The avoidance of waste in food is probably more urgent than the search for alternative sources of nitrogen. Dietary is more than the art of gratifying the palate, and while food must be both varied and appetizing, the question of alternative sources both of nitrogen and of fats is of importance to everyone. The dietary of the poor usually lacks a proper proportion of proteids, fats, and vegetables, and has an excess of starches. Hutchison says the cheapest sources of proteids, or tissue builders, are skim milk, fish, cheese, and the pulses when they can be digested, while margarine and dripping are the cheapest sources of energy.

The difficulty which lies in the way of special dietary is the barrier of individual taste. Only an invalid, and even an invalid only sometimes, will accept a prescribed form of dietary; but something might be urged in favor of a more frequent use of substantial soups, not the soup which stimulates appetite only, but that which affords substantial nourishment. Scotch broth or vegetable soup with bread, lentil soup, barley soup, potato soup, tomato soup thickened with flour or sago, are all satisfying and nourishing. Most cookery-books, I think, omit to point out the greater value of barley[4] and milk compared with rice and milk. Like most other foods, barley requires careful cooking. It is often badly cooked because hurriedly cooked. It should be burst with water, and boiled very slowly, avoiding too much water. Milk, in the quantity desired, should be added gradually, and salt or sugar according to taste. Badly cooked barley is both unpalatable and indigestible.

Cheese is another nutritious form of dietary, and may be cooked in a variety of ways. It has risen in price, but is rich in proteid and fats, and has a high calorie value.

Probably no food is more wasted than bread. Most households, I think, purchase too much at a time, and one cannot always live on bread pudding. It should be at least one day old when used. Syrup or treacle may occasionally replace butter. Both, like jam, are rich in sugar, which has a high calorie value, almost wholly available as a source of energy.

Potted meat has, unfortunately, gone out of fashion. It is rich in nitrogen and very nitritious, but requires careful preparation. It is also a cheap form of food, and the details of its composition are well known.

The question of cooking is too important to be introduced as a side issue, and is better taught in the classroom. Generally, it may be said that cooking diminishes the digestibility of animal foods but increases that of vegetables.

THE VALUE OF MANAGEMENT.

Economy in dietary, therefore, is very much an appeal to the individual, who must answer for himself whether in time of national emergency he is not using in a wasteful way, resources which should be applied to other ends. Individuals, however, are grouped in households, and it is the mother of the household who can decide what fraction of the three hundred millions we pay annually to foreign producers of imported food-stuffs can be retained in this country by a better use of home products.

	Proteid.	Fat.
[4] Barley meal	12.7	2
Pearl barley	7.3	1
Rice	5.0	0.8

Metastability of Metals*

By A. Vosmaer

FROM more than one point of view it is important to recognize that metals are not always as stable substances as they appear to be. Prof. E. Cohen of the Van't Hoff Laboratory, Utrecht, Holland, has carried out a large number of experiments bearing on the subject of metastability of metals and is continuing that work so that we may hope to have this difficult problem fully elucidated. It will be interesting and useful to the readers of this paper to be posted on the subject of allotropy of metals, since many a mystery in the world of metals has ceased to be such when the question of molecular transformation was considered.

The transformations of metalloids, such as carbon, phosphorus, sulphur, from one modification into another are familiar to most people, but not so the transformations of metals which, by the way, are usually much less marked.

The man who, in a cold winter, buys a lot of block tin to store it away, runs the risk of finding a mass of gray powder after some time, instead of the solid white blocks. In fact, this did occur in Europe in the winter of 1858 and gave rise to the rather difficult question whether or not tin in the white and in the gray state is one and the same substance. From a chemical standpoint it certainly is, but from a physical standpoint it certainly is not.

In fact, since we now have to admit that iron in the magnetized and the same in the non-magnetized condition cannot be called one and the same substance, the problem of defining substances becomes a more and more difficult task for the scientist and it has also a practical importance in the industry. For it should be borne in mind that scientific research work can be of great benefit to the practical man, since the theory of metals and alloys not only explains mysteries and faults, but it also prevents mistakes and may even cure them.

The Van't Hoff Laboratory, through its head, Prof. Cohen, has undertaken to study the question of metastability of metals and from the results published by the Royal Academy of Science of Amsterdam, we have prepared the following abstracts which give the gist of the results:

ALLOTROPY OF BISMUTH.

Dilatometric research showed a sudden change in volume at a temperature of about 75 deg. Cent., when the alpha bismuth, stable at temperatures below 75 deg. Cent., changes into the beta bismuth, stable at temperatures above 75 deg. Cent. The alpha bismuth has a specific gravity of 9.732, the beta form 9.712. This is a considerable difference; it confirms the results of the dilatometric measurements which showed that the change from alpha to beta is accompanied by an increase in volume.

If we bear in mind that the beta bismuth differs in properties from the alpha modification, and also that these molecular rearrangements take considerable time at temperatures lower than the transformation temperature proper, it is clear that as a rule commercial bismuth will always consist of a mixture of both modifications tending to reach equilibrium.

This explains why the physical constants of bismuth are as yet very far from being constant. Since the beta bismuth is a better electrical conductor than alpha bismuth, the specific conductivity of any sample of bismuth is bound to vary according to the ratio of alpha to beta bismuth in the sample.

Although the transition point is well defined at 75 deg. Cent., this does not mean that bismuth at a lower temperature does not contain any beta metal. On the contrary, as a rule all bismuth will always contain some beta as this form can very well exist in metastable condition.

On the other hand, it is noteworthy that the alpha bismuth may very well exist in metastable condition at temperatures above the transition point, even at temperatures as high as 150 deg. Cent.

In 1899 Perrot published his experience that the thermo-electric potential of cast bismuth changes after some time without any apparent cause. Now we know from Cohen's investigation that this strange behavior of bismuth is not strange at all. Perrot's bismuth evidently contained some beta bismuth which slowly but surely turned to the stable alpha bismuth condition.

Determinations of the specific gravity, the melting point, the Hall effect, etc., have to be revised. All properties of bismuth hitherto determined except the atomic weight must of necessity be corrected because not until 1913 was it known that all bismuth experimented upon may have consisted of a mixture—an undefined mixture—of alpha and beta bismuth.

We should remember the big difference between metals or alloys in the fluid state and in the solid state. It may very well be that in the fluid state all of the metal will be in the beta condition. On cooling down not all of the beta bismuth can find time to be converted to alpha bismuth and the beta condition is kept to a considerable extent in that form.

From a technical standpoint the change of specific gravity can be made use of. Every one familiar with castings knows the trouble caused by shrinkage; now bismuth and bismuth alloys possess the valuable property to expand on solidification; this, of course, gives rise to very sharp castings. It may be added that many of the fine Chinese metal castings of small objects for ornamental use contain bismuth. Unfortunately said change in volume—slight expansion on cooling—as observed by practical men in casting, cannot be explained by the allotropic change from beta to alpha bismuth at 75 deg. because it occurs at a much higher temperature and in a reverse sense.

It may be that there still is a third modification, gamma, of smaller specific volume than the beta and a second transition point a little below the melting point, but reports on bismuth do not mention this supposed third modification.

ALLOTROPY OF ANTIMONY.

There have been four different forms of antimony known for some years, but the correlation of these has not yet been established.

Cohen investigated in how far commercial antimony, also known as metallic antimony, is to be considered as a metastable system and he came to the conclusion that it is metastable.

The four allotropic modifications of antimony are the ordinary or metallic, the black, the yellow and the explosive. The latter three are all metastable at ordinary temperatures.

Cohen's determinations of density led him to say that antimony after chilling is in a form which changes at 100 deg. Cent. with a measurable velocity into a mass of different density. Probably about 96 deg. Cent. is the transition temperature.

The conclusion of this preliminary work is that antimony, as it is known in the familiar form, is a metastable system which consists of more than two allotropic forms. This is important in view of the extended use of antimony for alloys in technical arts.

Metals and alloys are judged, tested and paid for according to their properties and qualities. In case of dispute between buyer and seller in regard to quality the greatest embarrassment arises when authorities do not agree upon figures. But this will be unavoidable if metals are no longer what we think or thought them to be—definite substances. If a metal is a system of undefined composition as regards its own allotropic modifications, then we need not wonder about the discrepancies in physical constants and it is of the highest importance that the metal trade takes notice of the difficulties which may become traps in establishing definite figures.

ALLOTROPY OF POTASSIUM.

Potassium is a metal of only very small importance for industrial uses and probably never will play an important role, but it is of interest to know that this metal also is subject to allotropic modification. The metal potassium as it has hitherto been known is at ordinary temperatures a metastable system in consequence of the simultaneous presence of two forms, alpha and beta potassium.

ALLOTROPY OF COPPER.

It may surprise many people to learn that also in the case of copper we have a metal containing both alpha and beta copper, the transformation temperature being between 69.2 deg. and 71.7 deg. Cent.

In this, as in all cases, the transformation velocity depends largely on the presence of an electrolyte or of powdered metal which act as catalyzers. Under normal conditions the change of beta into alpha copper is so slow that it escapes notice unless specially looked for.

Remembering the changes undergone by tin and by zinc it is to be expected that bronzes and brasses will be subject to change as well.

* *Metallurgical and Chemical Engineering.*

Heat Transmission

An Economical Consideration of Fuel Economy and Temperature Regulation

THE subject of heat transmission will probably prove of constantly increasing importance in the future, both in its positive and negative aspects. The steam-driven prime mover is rapidly approaching a standard of efficiency which cannot be materially bettered, so that further decreases in fuel economy must be sought mainly in the boiler-room and its accessories. It is reported that the great Parsons steam-turbine at Chicago consumes, at full load, but 10.3 pounds of steam per kilowatt-hour, the designed operating conditions being a supply of steam at 200 pounds gage pressure and at 200 degrees superheat, with a vacuum of 29 inches. The generator efficiency being 0.961, the above figure is equivalent to a steam consumption of about 7.4 pounds per shaft horse-power hour. Taking 1,310 British thermal units as the total of the steam as supplied, and 47 British thermal units as the sensible heat of the condensate, this turbine consumes only 9,350 British thermal units per shaft horse-power hour. In this no allowance has been made for the power consumed in excitation and in operating the condenser, which may amount, say, to 2½ per cent in the aggregate. Making allowance for this, the heat consumption will amount to a total of about 9,600 British thermal units per hour. This figure is, no doubt, not the ultimate limit of economy possible, but the margin for further improvement is not large.

A good Diesel engine develops 1 shaft horse-power for about 8,400 British thermal units per hour, and has thus a substantial advantage from the standpoint of pure thermo-dynamics. This is enhanced by the circumstance that the steam-motor only derives its heat supply from the fuel indirectly and has to be debited with all the losses that occur in the transmission of heat from the fuel to the water, and from the boiler to the turbine stop-valve.

The best boiler efficiency recorded in the classical tests of Kennedy and Donkin was 82 per cent, which, however, was substantially above the average. In this trial, moreover, there were indications of a substantial loss by priming. In fact, the average of the figures observed by Kennedy and Donkin was under 70 per cent. Part of the loss is, no doubt, due to the fact that for the proper combustion of solid fuel a considerable excess of air is necessary, while with gaseous fuel the air supply can be adjusted into almost exact agreement with that theoretically required. Again, when solid fuel is used it is impossible to keep the rate of steam generation in precise agreement with the demand under varying loads, a matter which is easy with gaseous or liquid fuel. An oil-fired destroyer, for example, can, when running at full speed, be stopped for an hour and then resume her course at full power with the loss of but a very small quantity of steam. With coal-firing this is impossible, and the stand-by losses with coal-fired boilers are often very considerable.

It is in this direction that the internal-combustion engine possesses a great advantage. The producer *per se* is hardly more efficient than the boiler, but the stand-by losses are incomparably less. It is, in short, the boiler end of the stop-valve which offers the most promising field for a further reduction in power costs. No doubt, the future will see a very general improvement on the engine side, but this will consist in the main of a leveling up of practice to the heights already attained in individual instances, rather than in any very great improvement in the efficiency of the prime mover itself. In fact, it is possible to estimate with very extraordinary accuracy what additional improvement is possible here, and also the cost of attaining it. The most favorable factor is the continued increase in the size of units, which makes it commercially possible to aim at efficiencies the cost of which on a smaller scale would be prohibitive. At the best, though, an increase of 7 per cent in the efficiencies already recorded represents a limit which is very unlikely to be exceeded. By the use of very high pressures and superheats, such an increase in turbine efficiency might mean much more than a corresponding reduction in fuel consumption, but the problem of successfully dealing with these lies in the main on the boiler side of the stop-valve.

In the early days of the use of superheated steam, station engineers frequently asserted that, although the engine used less steam, the boiler did not take less coal, the increased losses by convection generally off-setting, in their opinion, most of the gain due to the higher efficiency of the engine. This view would hardly be maintained to-day, but from every point of view the prevention of avoidable losses of heat promises to play in the future a leading role in every manufacturing industry.

A striking instance of how serious neglect in this matter may be was afforded some twenty years or more ago by the failure of a large reciprocating engine to realize its guarantees. The builders knew that the engine should be capable of the duty demanded, but a representative sent over was unable to find anything out of order in the engine. He noted, however, that the steam-pipe was of unusually large size, and on substituting one of more ordinary proportions there was no difficulty in meeting the contract requirements. The large pipe surface, in short, caused such a loss of heat by what is commonly called "radiation" as to materially affect the engine economy.

This use of the term "radiation" is likely to give rise to much confusion in the future. In the strictly scientific sense, the energy lost by a hot body by radiation does not pass away in the shape of heat at all, radiant energy being merely light of long wave-length. Most of the loss from steam pipes is convected away by the air, or escapes by conduction. Some very exhaustive experiments on this subject have of recent years been made in the engineering laboratories of Manchester University, and an excellent summary of the results obtained was given by Prof. J. E. Petavel in a paper read before the Manchester Association of Engineers on October 30th, 1914. Experiments proved that in certain cases lagging a pipe may actually increase the heat loss from it, though only if the pipe diameter be very small. The advantage of an insulating covering increases with the diameter, but beyond 6 inches the rate of heat loss is much the same for all diameters. With a 6-inch pipe conveying steam at 100 pounds pressure the loss per degree of temperature difference between the steam and the air amounts, Prof. Petavel states, to 3.18 British thermal units per square foot per hour. With 200 pounds steam the loss from the same pipe is 3.35 British thermal units per square foot per hour, a figure which is increased to 3.70 British thermal units if the steam be superheated to 500 deg. Fahr. With a 1-inch pipe the corresponding figures are 3.72 British thermal units with steam at 100 pounds pressure, 3.93 British thermal units with steam at 200 pounds, and 4.30 British thermal units, if superheated to 500 deg. Fahr. Of the total loss, radiation proper does not account for more than about one sixth of the total. According to Prof. Petavel the true radiation loss may be taken as given by the relation

$$Q = 5.0 \times 10^{-1} S (T_1^4 - T_0^4),$$

where Q denotes the energy radiated expressed as British thermal units per hour, S the surface exposed, and T_1 and T_2 the absolute temperature of the surfaces between which radiation is interchanged.

It is very noteworthy that the loss due to the conductivity of the air may become very great with objects of small diameter. Thus, with a surface 1 inch in diameter and at 212 deg. Fahr., surrounded by air at 60 degrees, Prof. Petavel finds that of the total loss, 15 per cent is due to radiation, 4 per cent to the conductivity of the air, and 81 per cent to convection. With the same temperature conditions a wire 1-25 inch in diameter will lose 15 per cent by radiation, 43 per cent by the conductivity of the air, and 42 per cent by convection currents. With such surfaces as are met with in steam practice, however, the convective losses greatly predominate, and this predominance is enhanced if the surface be polished, which reduces the radiation losses by some 75 per cent.

When the hot object is surrounded by air under pressure, the rate of loss is greatly increased. Thus, a wire 1-20 inch in diameter at 2,000 deg. Fahr., surrounded by air at 140 atmospheres, loses heat at the rate of 140,000 British thermal units per square foot per hour, while in gaseous explosions, when the high temperature and pressure is accompanied by a violent eddying of the gases, a transmission of as much as 223,000 British thermal units has been measured per square foot of cooling surface exposed.

The figures above given relate to uncovered surfaces, and by the use of suitable insulating coverings can, in general, be greatly reduced. though, as already indicated, this rule does not apply to objects of very small diameter. With ordinary steam-pipes, however, a fair quality lagging will reduce the loss to one fifth of that of a bare pipe.

There are other fields in which the laws of heat transmission are fully as important as in power-station practice. A very interesting investigation was recently made in America as to how the output of workers was affected by temperature conditions. This was done by ascertaining the piece and bonus earnings of factory workers during different months of the year. There was found to be a close connection between the two. The maximum output was attained in the month of November, and then, disregarding a slight spurt at Christmastide, fell steadily to a minimum in January-February. It rose then steadily to a second but lower maximum in May, and with the advent of the hot weather fell to a second but lower minimum in June-July. The low winter maximum is, perhaps, partly due to the absence of daylight, and not merely to a lowering of the vitality by cold, but the summer maximum cannot be attributed to any other cause than the advent of hot weather. It is obvious, accordingly, that the maintenance of an equable temperature in factories is of very great commercial importance. In many industries this is a matter of difficulty, as many circumstances lead to a considerable development of heat within the factory walls. Boiler-rooms can be, and should be, isolated from the main building, and steam-pipes very thoroughly protected where they pass through rooms where operatives are at work. There are, however, other sources of heat. Prof. Petavel states that on an average the operative himself gives out as bodily heat about 500 British thermal units per hour, the amount depending, of course, on the effort exerted. Every machine is, moreover, a source of heat, practically the whole of the energy expended being gotten rid of in this form. A loom takes from one third to two thirds of a horse-power to drive, and each therefore liberates some 1,200 British thermal units per hour, and a spinning frame will similarly develop about 9,600 British thermal units per hour. Further, it is necessary in cotton-spinning to condition the air as to moisture, which is generally done by means of steam, and in the flax trade the hot-water troughs also liberate copious amounts of heat. The maintenance of a reasonable "climate" within such factories is, therefore, a matter of very considerable difficulty, and the results of observations quoted by Prof. Petavel are accordingly of very great interest.

The inside temperature depends upon the amount of ventilation provided and on the relation of the surface of the building to its volume. Prof. Petavel states that observations made during the summer of 1913 showed that in weaving sheds which had a wall and roof area of 100 square feet per loom, the temperature at the end of the day was some 24 degrees higher than in sheds exposing double this area.—*From Engineering.*

Bugs That Bore Into Leaded Cables.

A WIDELY published press dispatch recently announced the discovery by Albert Schuler, of Santa Barbara, Cal., of a bug which eats lead. At a recent meeting of telephone engineers at San Francisco, Mr. Schuler, who is manager of the Home Telephone System of Santa Barbara, reported the discovery of this strange bug and gave an account of its depredations, which in the newspapers was reported to be the real cause of so-called electrolysis.

Probably most engineers who read the newspaper story at once placed it in the same class with the famous and far-traveled hoax about "the worm that eats steel rails" which was perpetrated a quarter of a century ago and still reappears at intervals.

One of the editors of *Engineering News*, however, has since visited Santa Barbara and has seen the bugs, a number of which are held in captivity in lead boxes with glass covers, to see how long it will take them to bore their way to freedom. The bug is a slender black beetle, with hard wing covers, about ¼ inch long and of innocent and placid demeanor. Perhaps the reported alias of the marauder should be placed on record to aid in the detection of other members of the guild—*Sinoxylon declive.*

It is stated that what the bug does is to light on a lead-covered telephone cable and bore a tiny round hole through the lead sheath and the paper insulation down to the copper. Possibly he (the bug) believes the cable to be part of a tree or vine into which he is accustomed to bore holes, and so he proceeds to bore through the lead as he would through the bark. One entomologist gives concealment as the motive. Any engineer familiar with the rate at which the *Teredo navalis* can drive his boring apparatus through hard wood will see nothing impossible in a beetle boring into a lead cable covering.

Why the bug should want to bore holes is as yet an unexplained mystery, as it seems well nigh impossible that he could derive a high degree of nutrition from the lead, even if it did not make him sick. It is possible, however, that the boring process is preliminary to egg depositing, in which case the foregoing account is all wrong as to the bug's sex and apologies are due to her.

The lead borer has been heard of in South Bend, Ind., Rockford, Ill., in Omaha, Tacoma, Portland, San Diego, in Florida and far away Australia. Numbers of them have been found in old lead foil of tea packages and it is suspected that the family is of Oriental extraction. Quarantine is being considered to check the menace.—*Engineering News.*

A High Efficiency Induction Coil

With Detailed Instructions for Building

By Louis B. Laruncet, E.E.

ORDINARY induction coils, as well as all improved types of these instruments which can now be found in the trade, not only present the inconvenience of a very high cost, but their efficiency is very low (10 to 20 per cent of the input).

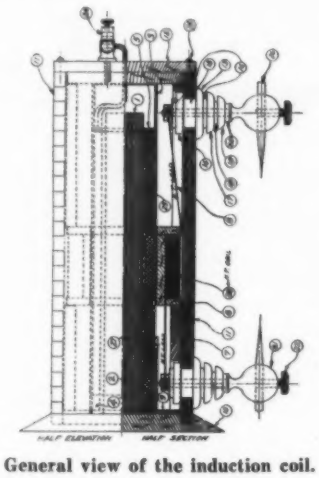
The induction coil described in this article has been designed by the writer after numerous experiments, and, together with a far greater efficiency than the commercial types, it presents the advantages of using a very small amount of small wire, and an insulating compound whose properties do not vary by use.

At the high tensions produced in large induction coils, solid insulating materials are quite easily perforated by electric waves, which, by slowly modifying the texture of said insulating materials, end by allowing the production of short circuits, thus putting the coil out of service. Liquid insulators, such as oil, must be put aside also on account of the currents flowing through said liquids between the extreme terminals of the secondary circuit, thus reducing the efficiency of the apparatus by a large amount. For these reasons, the writer made choice of an insulating compound in paste form (solution of paraffin in hot kerosene), which does not present the inconvenience of the liquids, and which, if perforated by a spark between the turns of the coil, spreads over such perforation, and makes that point safe again.

The construction of the coil will now be described, as this article is intended to be "PRACTICAL FIRST."

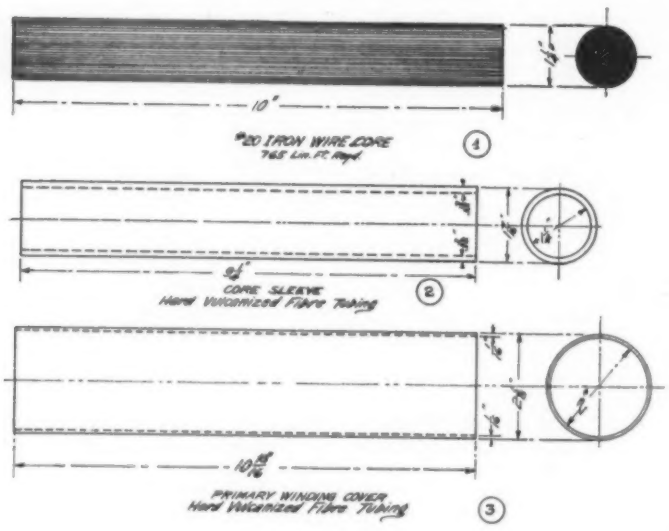
The materials required for the construction are as follows:

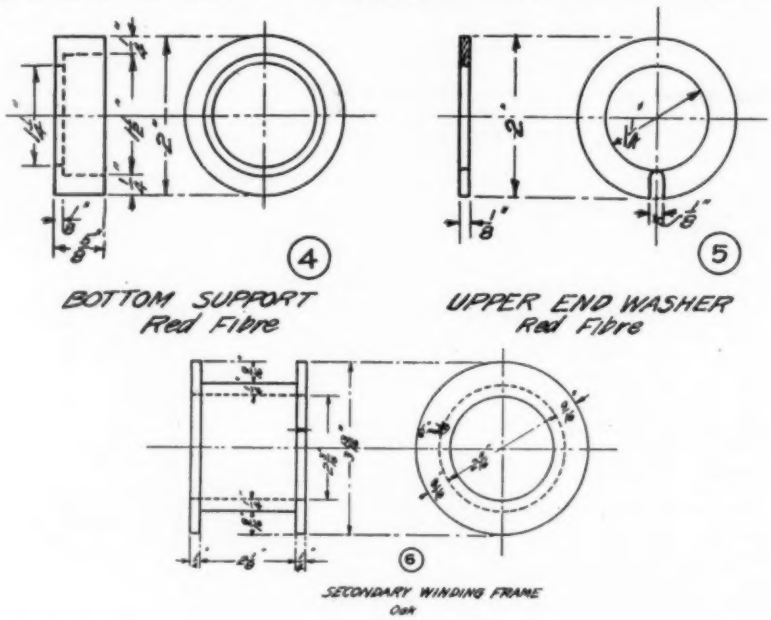
1. 765 lineal feet No. 20 BWG. Norway Iron Wire, cut to 10 inch lengths.
2. 1 fiber tube 1¼ inches diameter × 3/32 inch thick × 9¼ inches long.
3. 1 fiber tube 2 inches diameter × 1/16 inch thick × 10 13/16 inches long.
4. 1 fiber washer 2 inches diameter × 5/8 inch thick.
5. 1 fiber washer 2 inches diameter × 1/8 inch thick.
6. 1 oak secondary winding frame (mahogany or fiber can be used with equal advantage).
7. 4 fiber sheets 3 7/8 inches × 3½ inches ×3/8 inch thick.
8. 4 fiber sheets 3 7/8 inches × 4 11/16 inches × 3/8 inch thick.
9. 1 fiber sheet 3 7/8 inches × 3 7/8 inches × 1/8 inch thick.
10. 1 mahogany board 6 13/16 inches × 6 13/16 inches × 5/8 inch.
11. 4 mahogany boards 4 11/16 inches × 11 ¾ inches × 3/8 inch.
12. 1 mahogany board 4 11/16 inches × 4 11/16 inches × ¾ inch.
13. 2 fiber washers 1¾ inches diameter × ¼ inch thick.
14. 2 fiber washers 1 3/8 inches diameter × ¼ inch thick.
15. 2 fiber washers 1 inch diameter × 11/32 inch thick.
16. 4 fiber washers 1 inch diameter × 1/8 inch thick.
17. 2 fiber washers 1 3/8 inches diameter × ¼ inch thick.
18. 2 fiber washers ¾ inch diameter × 1/8 inch thick.
19. 2 fiber washers 1 1/8 inches diameter × ¼ inch thick.
20. 2 fiber washers 5/8 inch diameter × 1/8 inch thick.
21. 2 cast brass high tension terminals.
22. 2 binding screws for No. 21.
23. 4 hexagon brass check nuts for ¼ inch × No. 20 bolt, 1/8 inch thick, for No. 21.



General view of the induction coil.

24. 2 low tension binding posts with two openings for conductors and two binding screws as shown in general drawing.
25. 4 round head brass wood screws 5/32 inch × ¾ inch long.
26. 2 sparking points (these can be of any design or material, although steel or zinc needle points ¼ inch diameter × 2½ inches long are much recommended).
27. 1 fiber plate 3 1/16 inches × 3½ inches × 1/8 inch thick.
28. 2 pounds No. 34 B. & S. enameled magnet copper wire.
29. 70 lineal feet (about 2½ pounds) deltabeston, or triple cotton magnet copper wire.





The efficiency of the coil depends to a large extent upon the magnetic properties of the iron used in the construction of the core, and all means must be taken to make sure that the iron wire specified is perfectly "soft."

To obtain this result, take a 1½ inch iron pipe about 11 inches long, and put the wire cut in 10 inch lengths into this pipe. Plug the ends of the tube with clay, first filling the space between the wires with powdered clay. Place the tube so prepared into a good coke, not coal, fire, and leave it alone until the fire dies out, thus allowing the iron to cool off slowly, so that it is well annealed. Each wire must then be sandpapered to remove the excess oxide, dipped in boiling water, wiped dry, and coated with thin shellac while warm. The wires are then made up into a round bunch, and wrapped with thin bond paper fastened down with shellac. This bunch must not exceed 1 7/32 inches diameter at any point of its length. The bunch is then pushed down into sleeve (No. 2), so that it comes out 1/8 inch at the bottom end of the fiber tube, and 5/8 inch at the top. Washer (No. 4) is then placed on the bottom end, so that the iron core comes out flush with it, and that the fiber sleeve is covered up ½ inch by said washer (No. 4). Put washer (No. 5) on the upper end, and push it down until it meets with sleeve (No. 2), and, leaving a length of about 6 inches free, for future connections, wind 140 turns of the No. 10 magnet wire over this frame, in two layers of 70 turns each, beginning at washer (No. 5), and, of course, ending at the same place. The two ends of the coil are then pushed down in the slot in washer (No. 5), and the whole winding and core are dipped in thin shellac and allowed to dry. The fiber tube (No. 3) is then forced down over the winding, till it comes to 1/8 inch above the outside of washer (No. 4). On account of variations in the size of this tubing, it may be necessary to slightly reduce the diameter of washers (Nos. 4 and 5); this can be very easily done with a small fine file; taking care to preserve the circular shape of the washers. The wires are now bent to the shape shown in the general arrangement drawing, and drawn through the two 1/8 inch holes placed along the center line of the cover (No. 12). Attaching these wires to their respective binding posts (No. 24) completes the construction of the primary element.

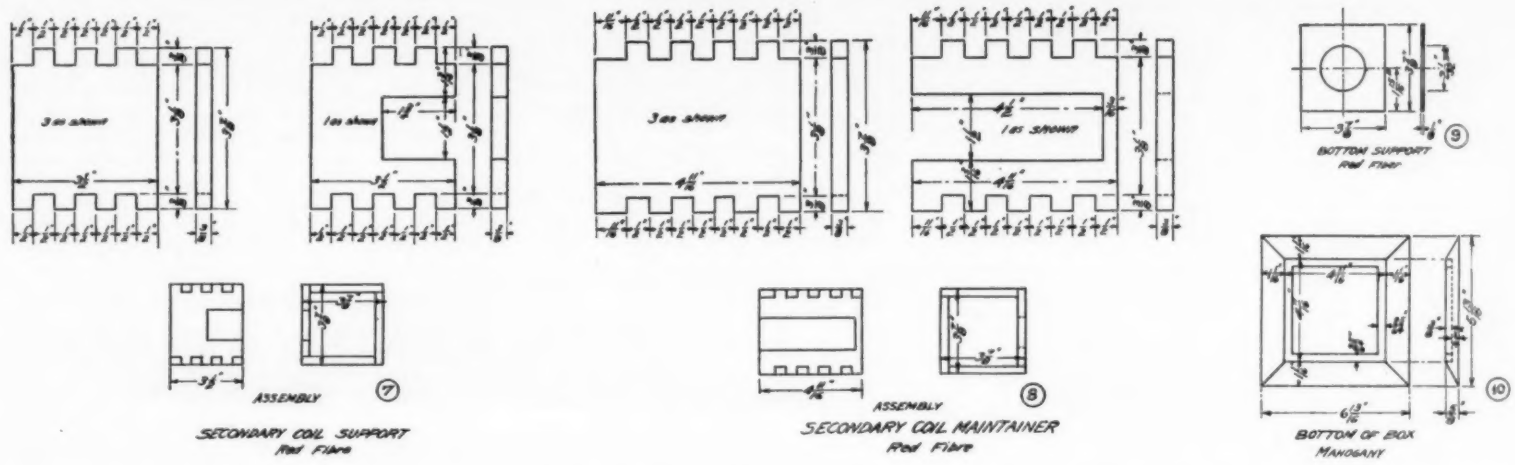
Now solder a piece of No. 18 or 20 double silk covered magnet wire about 18 inches long to each end of the No. 34 wire, painting this splice with good shellac. This piece of wire is coiled twice around the coil frame before coming out to the high tension terminals. This presents the advantage to have a conductor, less easily breakable than No. 34 wire, to bridge the distance between the coil and binding posts.

The so-prepared secondary wire is then coiled around frame (No. 6), the starting end being pushed through the 1/16 inch hole in the lower side of the frame, and a length of about 6 inches coming out, free, for connections. The winding of this coil, much similar to that of an ordinary spool of thread, must be done carefully so that the layers are definite, to avoid excessive electric strain on the insulation, and when a length of about 6 inches is all that is left, a piece of cotton or silk thread is used to bind the coil, and prevent its unwinding. Frame and coil are now immersed for 24 hours in the following mixture:

Kerosene (Hot)..... ¾ pound.
Paraffin wax..... 1 pound.

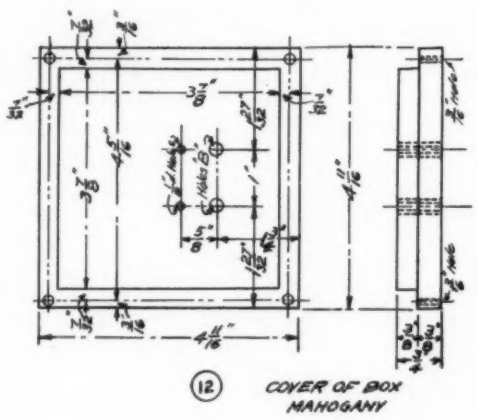
After the expiration of the time indicated, the mixture and the coil in it are allowed to cool off without disturbance.

The four sides (No. 11) of the mahogany container are then mounted together with a good glue, and given a coat of shellac. The upper high tension terminal is mounted in its place. The coil is then removed from its bath, and all excess of the insulating paste scraped off with great care. The coil is slipped into place, introducing it by the bottom of the box, taking care not to injure the insulating paste which covers the wires and to introduce first the side of the coil which has no hole in it, and the end of the wire which terminates the winding. The coil support (No. 7) is then pushed in, and the lower terminal mounted



in its place, connecting the wire which comes out of the coil frame by the 1/16 inch hole in the lower flange with this terminal, and to tighten the check nuts securely. Before connecting the high tension wire to the terminal, care must be taken that support (No. 7) is pushed in ½ inch from the edges of the sides of the box, and a good practice would be to slip a small rubber tube over the wire. The other conductor is now attached to the upper high tension terminal, taking care that the coil does not move, and not stretching the wire too tight. The remark about a small rubber tube applies to this wire also. Retainer (No. 8) is now slipped down into place, and the primary coil, with the core, and the box cover attached, lowered carefully in its place, as shown in the assembly drawing. Piece (No. 27) is then placed as shown, and then washer (No. 9) closes the whole thing. The connections are then tested in the usual way with a cell and bell, and if satisfactory, the bottom of the box can be put on. The grooves in that bottom (No. 10) are painted with a good glue, and the box is forced in them. The wood screws (No. 25) are then driven in, thus making the cover tight, and the apparatus is allowed to dry over night. It is then cleaned and polished all over the outside surface, and the sparking points are put in the high tension terminals. The coil is complete.

This induction coil gives a spark from 9 to 10 inches long; not a bluish spark, but a big, fat, intensely white

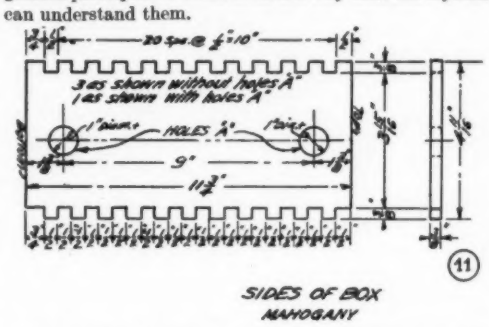


one; with a power consumption of 6 volts 3 amperes; i. e., 18 watts.

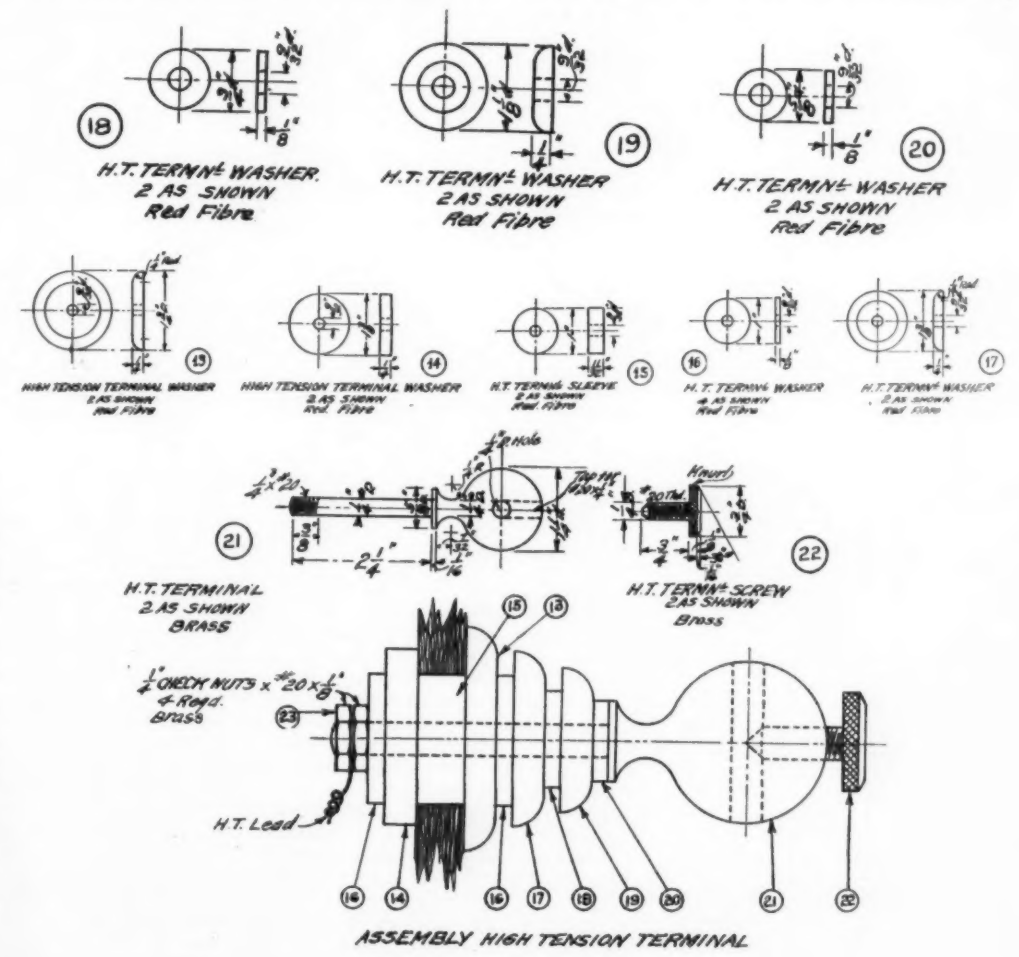
The high tension winding of an ordinary Ruhmkorff coil of same output would consist of 50 to 60 flat coils, or "cakes," connected in tension, and separated by solid partitions. The amount of secondary wire used would be between 10 and 14 pounds; the power consumption about 120 watts.

Transformers and induction coils having only one secondary coil, or several coils mounted in parallel, present a very peculiar property: Between the ground and the terminal of the secondary coil corresponding to the starting point of the winding, i. e., the one nearest to the primary circuit, sparks are obtained which are about ten times shorter than the ones obtained between the ground and the other terminal of the coil. Some scientists have named the terminals, on account of this property, low tension pole, and high tension pole, respectively. On the other hand, if the low tension pole is grounded, the tension at the high tension pole increases, and the spark between the two poles seems to gain in volume and color. This is why, in the present design, the writer has instructed to connect the starting point of the high tension winding to the lower terminal of the coil, thus making it easy to ground this low tension pole, if desired, without interference with other wires or apparatus.

The high efficiency of the coil described, as well as the small amount of material required for its construction, may seem quite peculiar, and the explanation how such results are obtained requires a complicated discussion, involving formulæ and rules by far too technical to be given out here, but the writer will try to present the general principles of these in such a way that the layman can understand them.

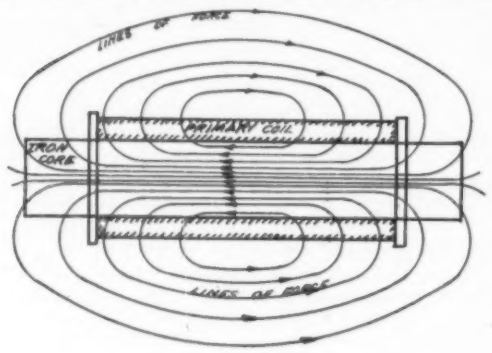


The length of the spark and its volume depend on five principal things, namely: First, the rapidity of decrease of the current flowing through the primary coil; second, the amount of power utilized; third, the proportion of the number of turns of wire of the primary circuit to that of the secondary winding; fourth, the section of the iron core; fifth, the amount of magnetic leakage. The rapidity of decrease of the current in the primary coil depends on two more things: First, the sharpness of break of the interrupter; second, the choking effect of the coils upon the electric current; the smaller this choking effect, the quicker the decrease of primary current, and this choking effect is in direct proportion with the number of turns of the coils, and the sectional area of the iron of the core. Unfortunately, the size of the spark is in direct proportion with this sectional area, and with the number of turns of the secondary coil also, and if either one is increased, the tendency of the spark to increase is counteracted by the choking effect which tends to slow down the decrease of the primary current. There is a point, however, where the proportion between these contrary effects can be such that a maximum spark can be obtained, and this condition, which is obtained in the present coil, is quite hard to obtain exactly. Now, the length of the spark depends also on the magnetic leakage, and the reason why is quite simple. When current is sent through the primary winding, magnetic lines of force are set up in the iron core, and this magnetism reacts on the secondary circuit and sets up the high voltage which causes the sparking. Now, the magnetic lines of force set up in the core do not travel in a straight line, but follow directions such as are shown in sketch "A"; that is a large amount of the lines curve out and do not thread through all the turns of the winding. This is called magnetic leakage since it is a loss of power for the secondary winding. From inspection of this sketch, it is evident that should the secondary coil extend all over the primary



right up to the ends of the core, a great number of lines of force would not thread through its ends, and that means that practically no voltage would be set up in these turns. Consequently, these ends can be cut off without great loss

of power, thus leaving a far smaller secondary winding, with practically the same effect as the first one. Bunching all the turns of a long secondary coil in the center of the core does not give an induction coil much more powerful than the regular one, for the diameter of the coil is increased, and for the same amount of wire, the number of secondary turns, and consequently the voltage is reduced. However, by partially bunching together the turns of the secondary, and spreading out those of the primary, the magnetic leakage is reduced by a large amount. This is another of the good points of the coil already described.



SKETCH "A"

As to the proportion of primary turns to secondary turns, the writer firmly believes, and the results obtained seem to prove it, to have figured out quite an efficient combination, and from tests made with very delicate apparatus, the magnetic leakage from the secondary coil has been found not to exceed 0.01 per cent, or one ten-thousandths of the maximum amount of lines of force set up in the iron core.

It has been said before that the length of the spark depends on the sharpness of break of the interrupter also, and it must be added that the total efficiency of the coil depends too on the proper working of said interrupter. For instance, if an interrupter of the spring type, or similar, does not work regularly, but moves either too slow or too fast, in the first case, the period of contact will be too long, and the primary current will not only reach its maximum value, but it will be maintained at this value for some time, and the break, or rupture period, will be equally too long. In this case, so long as the primary current does not vary, there is no inductive effect on the secondary circuit; hence, the power sent through the coil will be wasted and transformed into heat which is very objectionable, and at the same time, the breaking period being too long, the decrease of current in the primary coil will take more time to be effected, and the secondary voltage, and consequently the spark will be reduced. In the second case, the interrupter vibrating too quickly, the primary current will not have enough time to attain its maximum value, and although the break is very sharp, the resultant secondary voltage will be small. In both cases, the power of the coil will be far below that rated, and undue heating will be developed as in the first case. It is consequently of the utmost importance that the interrupter be of the highest grade obtainable.

The writer, with an interrupter of the rotating type, quite similar to a rotary spark gap, but having only two contact strips along the circumference of the rotating disk, one of the contact brushes being made movable so as to adjust the duration of primary current without altering the sharpness of the break, has used a 10 inch spark induction coil built exactly like the one described, for the production of high frequency currents, X rays, etc., for over one year, working about 5 hours per day, without the slightest trouble or repair, the coil always giving the same length of spark after being once adjusted and without any undue power consumption or heating.

Whichever be the type of interrupter used, it should always have two entirely independent adjustments:

(*a*) Duration of current,

(*b*) Sharpness of break,

if best results are desired.

Nothing has been said as yet about a condenser; this is, however, absolutely necessary to improve the efficiency of the coil, and avoid bad sparking at the interrupter. For a coil such as the one just described, the condenser can be made of 200 pieces of tin foil, 9 inches × 10 inches, connected up in the usual way, and separated from each other by 10 inch × 9½ inch pieces of good bond paper soaked in melted beeswax.

Vulcanized Fiber*

DESPITE the fact that the annual production of vulcanized fiber in this country exceeds 15,000,000 pounds, comparatively little is known either of the method of manufacture or the properties of this widely used material. Books on industrial chemistry or cellulose products, as a rule, dismiss the subject with a few words, often inaccurate or misleading, and give in many cases the impression that vulcanized fiber is still largely in a visionary stage, interesting chiefly from the theoretical standpoint.

Vulcanized fiber was invented by an English chemist named Taylor about the year 1869, but its commercial development dates from 1873. Although the original patents included the use of sulphuric or nitric acids with or without the addition of various metallic salts, the process as practiced today is confined to the action of zinc chloride on an all cotton cellulose paper, unsized and unloaded.

This paper is passed over heated cylinders through a bath of zinc chloride maintained at about 70 deg. Baumé and 40 deg. Cent., depending upon the quality of the paper and the atmospheric conditions. It is then rolled up over large heated drums to the desired thickness, the zinc chloride hydrolyzing the cellulose and gelatinizing the surface to such an extent that the paper unites together and forms an almost homogeneous mass. Fiber tubes are made in a similar manner by substituting for the large drums, mandrels of the proper size to give the desired inside diameter.

The "green fiber" is then washed in zinc chloride baths of progressively diminishing concentration until it is commercially pure, i. e., contains less than 0.15 per cent chlorine. This process is of necessity very slow, and any attempts to expedite it are apt to result in an inferior grade of fiber or in blisters due to the increased osmotic pressure. One quarter inch fiber, for instance, requires three to four weeks for washing, and 2-inch fiber six to eight months. The wet pure fiber is dried at a temperature of 40 deg. to 60 deg. Cent., after which it is pressed and usually calendered.

The finished product which has shrunk to one half its original thickness is a homogeneous, tough, horn-like material which can be readily machined, threaded, embossed, etc., and which can be given a high polish.

Vulcanized fiber is not waterproof, but is not injured by immersion in water, either hot or cold, and on redrying resumes its original dimensions and properties. Neutral salts are also without any harmful effect, but most mineral acids in time cause disintegration. Organic solvents, such as ether, carbon tetrachloride, etc., and all oils are absolutely without effect on fiber, and are not absorbed in the slightest degree.

The mechanical and physical properties may be varied between fairly wide limits by proper manipulation of the chemical treatment and by varying the quality of the original paper. This fact is little appreciated by the public, and, in fact, only too little appreciated by some of the fiber manufacturers themselves. Consequently a man believing that "fiber is fiber" may purchase a grade absolutely unsuited for his particular needs, and without further investigation conclude that all fiber is worthless to him. To illustrate this point more strongly, we give in the table the properties for two samples of material both of which sell under the name of vulcanized fiber.

PROPERTIES OF TWO KINDS OF VULCANIZED FIBER

	No. 1	No. 2
Thickness	⅛ in.	⅛ in.
Specific gravity	1.100	1.480
24 hours' absorption of water	70 %	25 %
Chlorine content	0.20%	0.03%
Hardness by scleroscope	25	50
Shearing strength, lbs. per sq. in.	9,000	13,000
Crushing strength, lbs. per sq. in.	33,000	43,000
Tensile strength, lbs. per sq. in.	8,000	13,000
Breakdown voltage	12,500	50,000

At a glance it will be seen that there are great differences in the properties of the two samples, and that the purchaser of fiber must take care how and where he buys in order to be sure that the manufacturer is able to and actually does give him the grade best adapted to his purposes.

Vulcanized fiber is used in all kinds of electrical insulation; in trunks, roving cans, waste baskets and similar receptacles; and in a great variety of mechanical parts such as gears, valves, washers, bushings, etc. One of its principal applications is in railroad insulation for automatic block signals, shims, etc. Vulcanized fiber gears are noiseless and oil-proof, and on account of their toughness and elasticity will outwear two or three sets of brass gears. Vulcanized fiber valves have given continuous service for over three years in feed-water pumps, pumping hot water at 212 deg. Fahr., against 150 pounds pressure, and are far superior to rubber or composition valves for water or any neutral solution.

The tensile strength of vulcanized fiber which is three times that of leather, and its high dielectric strength of 200 to 400 volts per mil, are constantly leading manufacturers as they become more familiar with this interesting material, to adopt it for new uses.

* By Charles Almy, Jr., in *Metallurgical and Chemical Engineering.*

A Material for Ships' Propellers

AN alloy that has proven very satisfactory for ships' propellers is turbadium bronze. This material has a tensile strength of 35 to 42 tons with an elongation of 14 to 20 per cent on a 2-inch test piece, and it is not appreciably corroded by sea water. According to the *Chemical News* its composition is, approximately, copper, 48 per cent; zinc, 46.45 per cent; tin, 0.5 per cent; lead, 0.1 per cent; iron, 1 per cent; aluminium, 0.2 per cent; manganese, 1.75 per cent; nickel, 2 per cent.

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